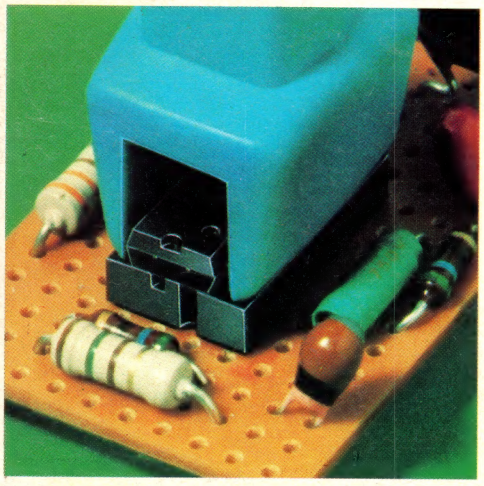
Australia $1.50 Malaysia $4.95 IR £1.26 (inc. VAT)

PRACTICAL

ELECTRONICS

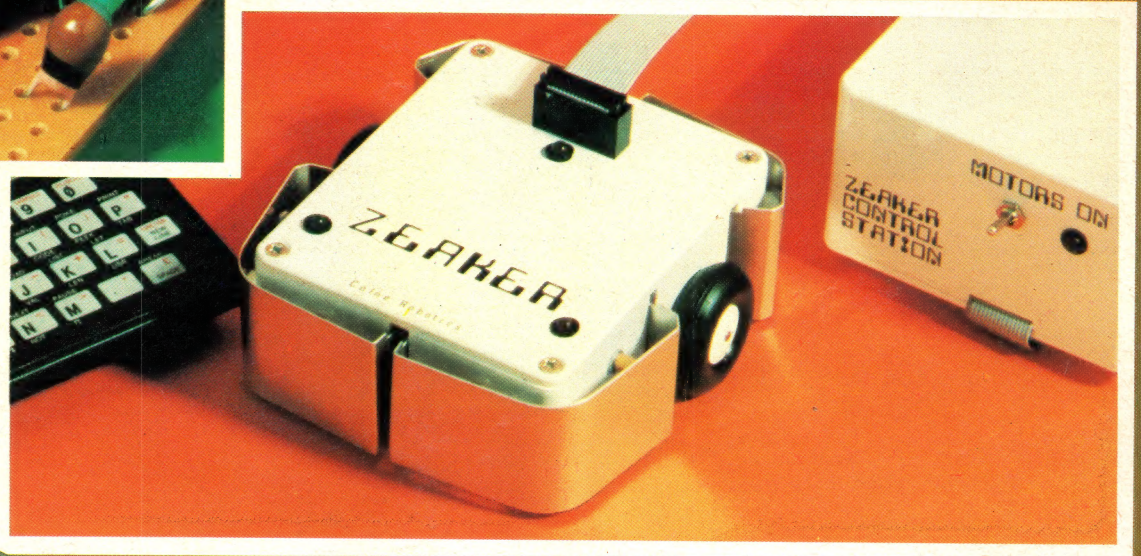
MAY 1983

85p



New Feature

SEMICONDUCTOR CIRCUITS ... USING CHIPS



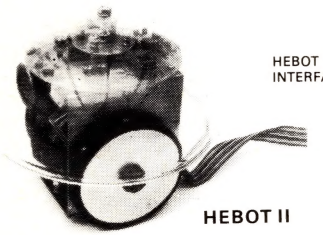
PROJECTS • AUTOMOBILE TEST SET • PERSONAL STEREO AMPLIFIER • MAINS WATCHDOG • COMPUTING ZEAKER MICRO-ROBOT • ULTIMUM MICROPROMPT • NEWS & FEATURES • SPACEWATCH MICROFILE • PATENTS REVIEW • INDUSTRY NOTEBOOK

EXTRA! – EDITORIAL PAGES – EXTRA!

Get moving with these new developments in UK Robotics

— advanced electrohydraulic designs for education, industry and now available to the home constructor.

Hebot II is a turtle-type robot which takes programming out of the two dimensional world of the VDU into the real three dimensional world. Given a DC supply of 9-15V it can perform a bewildering number of moves under computer control — forwards, backwards, left and right — with each wheel independently controlled. It has blinking eyes, bleeps with a choice of two tones and has a solenoid operated pen to chart its progress. Touch sensors coupled to its shell return data about its environment to the computer for it to calculate evasive or exploratory action. Hebot II connects directly to an I/O port or alternatively with the universal interface board to the expansion bus of a ZX81 or other computer.

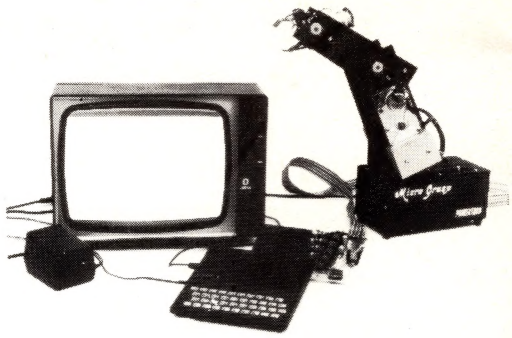


HEBOT KIT £85.00
INTERFACE BOARD KIT £10.00

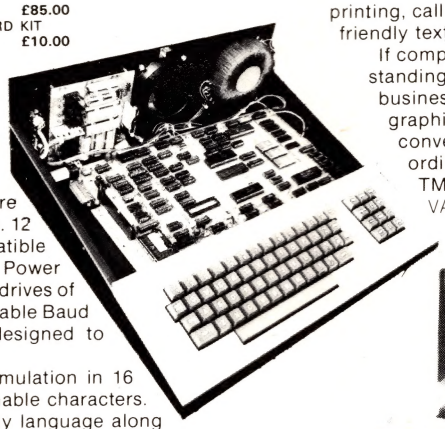
HEBOT II

Robotic experience is becoming as essential a subject as computing. MICROGRASP provides the lowest cost means of acquiring that experience but despite its ultra low price the robot has considerable versatility. There are 5 axes each using a servo motor and there is feedback from each of the arm movements. Control is by any computer with an expansion bus – the ZX81 being particularly suitable. Servoing is achieved with hardware on the interface board to keep programming simple and the robot is operated under BASIC commands with no computer specific software required. The interface board is memory mapped using only 64 bytes at any of 1024 switch selectable locations.

MICROGRASP robot kit with power supply	£145.00
Universal computer interface board kit	£48.50
23 way edge connector	£2.50
ZX81 peripheral/RAM Pack splitter board	£3.00



MICROGRASP, INTERFACE BOARD AND ZX81



Up to the nano-second hard, firm and software developments embodied in a complete system. 12 Mega Hertz 16 bit CPU; 64K upwardly compatible DRAM; separate 16K video DRAM and 24K TI Power Basic with overwrite. Supports up to four Disc drives of mixed type with 16 serial I/O ports. Programmable Baud rate and comprehensive E Bus interface designed to support real world applications.

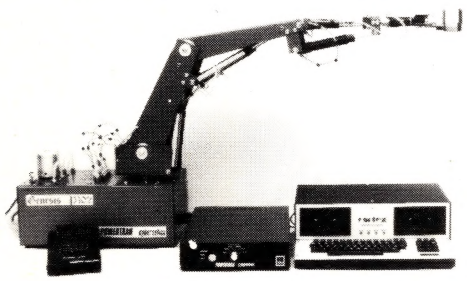
Very high resolution graphics gives 3D simulation in 16 colours on 36 prioritised planes of user definable characters. Software FORTH coming includes this trendy language along with NOS C/PM.

Hardware components available separately with details in Nov, Dec, and Jan issues of ETI. Software features include; Real time clock, full renumber command, buffered I/O to free machine whilst printing, call to machine code routines, hexadecimal support and user-friendly textual error trapping messages.

If computers interest you then the Cortex will expand your understanding infinitely more than off the shelf machines. Use it in business, education, research or just play with the incredible graphics capability. At Powertran we are using these machines in conventional roles, in product control and R & D. We shall co-ordinate the Cortex user group and distribute software for the TMS 9995 CPU. Complete 16 bit 64K computer kit **£295.00** + VAT. Complete 16 bit 64K computer ready built **£395.00** + VAT.

Top of the range is the Genesis P102 which has dual speed control, continuous servo operation and double acting cylinders for increased torque on the wrist and arm rotation joints. The microprocessor based control system has additional memory, position interrogation via the RS232C interface increasing the versatility of computer control and inputs are provided for machine tool interfacing.

6 axis system READY BUILT £1950.00
Powertran CORTEX 16 bit 64K computer Kit **£295.00** READY BUILT **£395.00**
(Electronics Today International December issue on CORTEX)



GENESIS P102 PROCESSOR BOX, HAND HELD CONTROLLER AND CORTEX COMPUTER

Example prices and specifications

Genesis S101
Base: 19.5″ × 11″ × 7.5″
Lifting capacity: 1500gm
Arm lift: 6.6″
Weight: 29Kg

4 axis model in kit form	£425
5 axis model in kit form	£475

Genesis P101
Base: 19.5″ × 11″ × 7.5″
Lifting capacity: 2000gm
Arm lengths between axles: 14.0″
Weight: 34Kg

6 axis model in kit form	£675

Complete Systems as shown in Photograph on right

Genesis S101

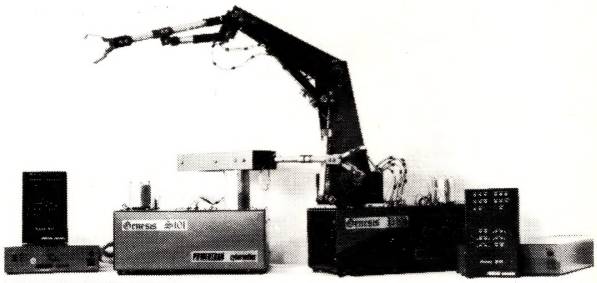
4 axis system in kit form	£681.50
5 axis system in kit form	£737.50
5 axis system Ready Built	£1450

Genesis P101

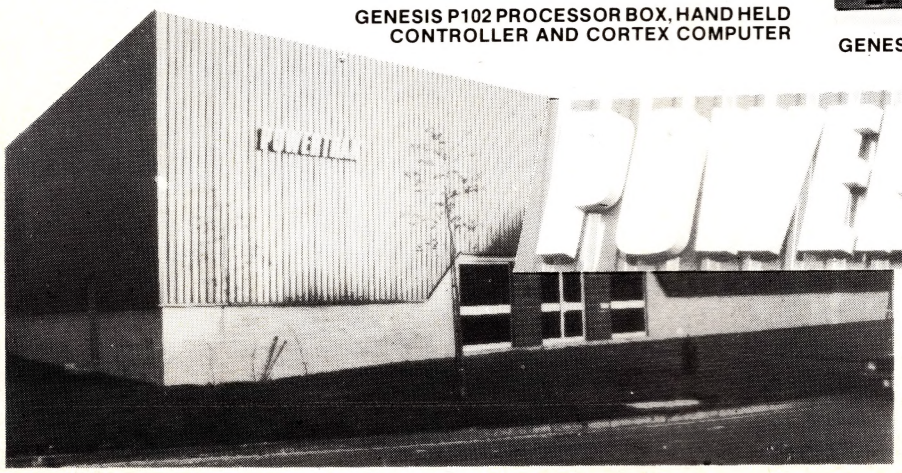
6 axis system in kit form	£945.00
6 axis system Ready Built	£1650

All prices exclusive of VAT

With prices starting below £1,000 the Genesis range of general purpose robots provide a first rate introduction to robotics for both education and industry. Each has a self-contained hydraulic power source which enables loads of several pounds to be smoothly handled. The system operated from a single phase 240 or 120V AC supply or a 12V DC supply. The machine can be supplied with up to 6 axes each of which is fully independent but capable of simultaneous operation. Position control is achieved by means of a closed-loop feedback system based around a dedicated microprocessor. Movement sequences can be entered, stored and replayed by use of a hand held controller, alternatively the systems can also be interfaced to an external computer via a standard RS 232C link.



GENESIS S101 AND GENESIS P101 WITH PROCESSOR BOXES AND HAND-HELD CONTROLLERS



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TELEX: 477407 ZENMON

PRACTICAL
ELECTRONICS
VOLUME 19 No. 5 MAY 1983

CONSTRUCTIONAL PROJECTS

DIGIT TALKER *by A. Wiggin* **21**
Interface system
AUTOMOBILE TEST SET *by M. Tooley BA and D. Whitfield MA MSc* **34**
Offers a test facility for car electrics
ZEAKER *by David Buckley* **42**
Low cost computer controlled robot
MAINS WATCHDOG *by Chris Lare* **50**
Audio/visual warning system for mains failures
PERSONAL STEREO AMPLIFIER *by R. A. Penfold* **55**
General purpose 6 watts per channel system
ULTIMUM *by William Edwards* **70**
Three chip sound generator

GENERAL FEATURES

SEMICONDUCTOR CIRCUITS *by Tom Gaskell BA(Hons)* **26**
Combination lock (LS7225): 3 tone chime (SAB0600)
MICROBUS *by DJD* **48**
A bi-monthly focus on micro's for the home constructor
INTO THE REAL WORLD *by M. Tooley BA and D. Whitfield MA MSc* **62**
Conclusion of series

NEWS AND COMMENT

EDITORIAL **15**
NEWS AND MARKET PLACE **16**
Including Countdown
BAZAAR **25, 30, 39, 59**
Free readers' advertisements
SPACEWATCH *by Frank W. Hyde* **32**
Extra-terrestrial activities chronicled
INDUSTRY NOTEBOOK *by Nexus* **40**
News and views on the electronics industry
SPECIAL OFFER—CASSETTES **53**
PATENTS REVIEW **60**
TV Warning and Automatic Cut-Out
MICROCONTROLLER DATA SHEET 4 *by M. Tooley BA and D. Whitfield MA MSc* **69**

We regret that due to circumstances beyond our control we are unable to publish Micro-file this month

OUR JUNE ISSUE WILL BE ON SALE FRIDAY, MAY 6th, 1983

(for details of contents see page 31)

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POLYESTER CAPACITORS: (Axial Lead) 400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 **11p;** 10n, 15n, 18n, 22n **12p;** 33n, 47n, 68n **16p;** 100n, 150n **20p;** 220n **30p;** 330n **42p;** 470n **52p;** 680n **60p;** 1μF **68p;** 2μ2, 4μ7 **85p.** **1000V:** 1nF **17p;** 10nF **30p;** 15n **40p;** 22n **36p;** 33n **42p;** 47n, 100n **50p.**

POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p;** 33n, 47n, 68n, 100n **7p;** 150n, 220n **10p;** 330n, 470n **13p;** 680n **19p;** 1μ **23p;** 1μ5 **40p;** 2μ2 **46p.**

ELECTROLYTIC CAPACITORS (Values in μF). **500V:** 10μF **52p;** 47 **78p;** **63V:** 0·47, 1·0, 1·5, 2·2, 3·3, **8p;** 4·7 **9p;** 10 **10p;** 15, 22 **12p;** 33 **15p;** 47 **12p;** 68 **16p;** 100 **19p;** 220 **26p;** 1000 **70p;** 2200 **99p;** **50V:** 68 **20p;** 100 **17p;** 220 **24p;** **40V:** 6·8 **15p;** 22 **9p;** 33 **12p;** 330, 470 **32p;** 1000 **48p;** 2200 **90p;** **25V: 50p;** 3300 **76p;** 4700 **92p;** **16V:** 2·5, 40 **8p;** 47, 68, 100 **9p;** 125 **12p;** 220 **13p;** 330 **16p;** 470 **20p;** 680 **34p;** 1000 **27p;** 1500 **31p;** 2200 **36p;** 4700 **79p.**

TAG-END TYPE: 64V: 4700 **245p;** 3300 **198p;** 2200 **139p;** **50V:** 3300 **154p;** 2200 **110p;** **40V:** 4700 **160p;** **25V:** 4700 **98p;** 10,000 **320p;** 15,000 **345p.**

TANTALUM BEAD CAPACITORS:
35V: 0·1μ, 0·22, 0·33 **15p;** 0·47, 0·68, 1·0, 1·5 **16p;** 2·2, 3·3 **18p;** 4·7, 6·8 **22p;** 10 **28p;** **16V:** 2·2, 3·3, **16p;** 4·7, 6·8, 10 **18p;** 15 **36p;** 22 **30p;** 33, 47 **40p;** 100 **75p;** 220 **88p;** **10V:** 15, 22 **26p;** 33, 47 **35p;** 100 **55p.**

SILVER MICA (pf)
2, 3·3, 4·7, 6·8, 8·2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180 **15p each**
220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p each**
1000, 1200, 1800 **30p each**
3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors.
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n,15n, 22n **7p;** 18n, 27n, 33n, 47n **8p;** 39n, 56n, 68n **9p.**
100V: 100n, 120n, **10p;** 150n **11p;** 220n **13p;** 330n **18p;** 470n **23p;** 680n **30p;** 1μF **34p;** 2μ2 **50p.**

CERAMIC Capacitors: 50V
Range 1pF to 6800pF **4p;** 10nF, 15n, 33n, 47nF **5p;** 100nf/30V **5p.**

POLYSTYRENE Caps:
10pF to 1nF **8p**
1n5 to 12nF **10p**

POTENTIOMETERS: Carbon Track, 0·25W Log & Linear Values.

500Ω, 1K & 2K (LIN ONLY) Single	**30p**
5KΩ-2MΩ single gang	**30p**
5KΩ-2MΩ single gang D/P switch	**78p**
5KΩ-2MΩ dual gang stereo	**88p**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track
5KΩ-500KΩ Single gang **70p**
10KΩ-500KΩ Dual gang **110p**

PRESET POTENTIOMETERS
0·1W 50Ω-2·2M Mini Vert. & Horiz. **7p**
0·25W 100Ω-3·3MΩ Horiz. larger **10p**
0·25W 250Ω-4·7MΩ Vert. **10p**

RESISTORS
Hi-stab, Miniature, 5%, Carbon.

	RANGE	Val.	1-99	100+
0·25W	2Ω2-4·M7	E24	**2p**	**1p**
0·5W	2Ω2-4·M7	E12	**2p**	**1p**
1W	2Ω2-10M	E12	**6p**	**4p**
2% Metal Film	10Ω-1M		**6p**	**4p**
1% Metal Film	51Ω-1M		**8p**	**6p**

RESISTORS S.I.L. Package: 7 Commoned, 100Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **24p.**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **26p.**

TRANSISTORS

AC125/6	35	BC214L	10
AC127/8	35	BC237/8	14
AC141/2	30	BC307B	14
AC176	28	BC308B	16
AC187/8	32	BC327/8	15
ACY17/18	70	BC337/8	15
ACY19/20	75	BC441	34
ACY21/22	75	BC461	34
AD142	120	BC477/8	40
AD149	79	BC516/7	40
AD161/2	42	BC547/8	12
AF118	95	BC549C	14
AF139	40	BC556/7	15
AF239	55	BC558/9	15
BC107/8	10	BCY70	16
BC107B	12	BCY71/2	20
BC108B	12	BD124	115
BC108C	10	BD131/2	48
BC109	10	BD133	60
BC109B	12	BD135	45
BC109C	12	BD136/7	40
BC117/8	20	BD138/9	40
BC140/42	30	BD140	40
BC147/8	9	BD245	45
BC147B	10	BD378	70
BC148C	10	BD695A	125
BC149	9	BD696A	125
BC149C	12	BF180	38
BC153/4	27	BF194/5	12
BC157/8	10	BF198/9	18
BC159	11	BF200	30
BC167A	10	BF224	25
BC168C	10	BF244A	28
BC169C	10	BF244B	29
BC170	15	BF256B	35
BC171/2	11	BF257/8	32
BC173	11	BF259	35
BC177/8	16	BF336	40
BC179/81	20	BF594/5	30
BC182/3	10	BFR90/40	23
BC184	10	BFR41/79	23
BC182L	10	BFR80/81	25
BC183L	10	BFR98	105
BC184L	10	BFX29/84	28
BC186/7	26	BFX85/86	28
BC212/3	10	BFX87/88	28
BC212L	10	BFY50/51	23
BC213L	10	BFY52	23
BC214	10	BFY56	32
BFY64	35	TIP34C	88
BFY81	120	TIP35A	110
BFY90	80	TIP35C	128
BRY39	40	TIP36A	130
BSX20	20	TIP36C	140
BSX29	34	TIP41A	50
BU105	170	TIP41B	52
BU205	190	TIP42A	55
BU206	200	TIP42B	58
BU208	200	TIP120	70
MD8001	250	TIP121	73
MJ2955	70	TIP141	105
MJE340	54	TIP142	105
MJE370	100	TIP147	120
MJE371	100	TIP2955	60
MJE520	95	TIP3055	60
MJE2955	99	TIS43	32
MJE3055	70	TIS44	45
MPF102	40	TIS88A	50
MPF103/4	30	TIS90	30
MPF105	30	TIS91/93	32
MPF106	40	VK1010	80
MPSA05	25	VN10KM	55
MPSA06	25	VN46AF	78
MPSA12	32	VN66AF	80
MPSA55	30	VN88AF	94
MPSA56	30	VN89AF	96
MPSA70	30	ZTX107/8	11
MPSU02	58	ZTX109	12
MPSU05	55	ZTX212	28
MPSU06	55	ZTX300	13
MPSU52	65	ZTX301/2	16
MPSU55	60	ZTX303	25
MPSU56	60	ZTX304	17
OC23	170	ZTX320/26	30
OC28/36	220	ZTX451	23
OC41/42	75	ZTX500/1	14
OC44	75	ZTX502/3	18
OC70	40	ZTX504	25
OC76	50	ZTX531	25
OC81/82	50	ZTX550	25
OC83/84	40	2N696	30
PF29A	32	2N697	23
PF29C	38	2N698	40
PF30A	35	2N699	48
PF30C	37	2N706A	19
PF31A	38	2N708	19
PF31C	37	2N914/5	32
PF32A	38	2N918	35
PF32C	42	2N930	20
PF33A	65	2N1131/2	24
PF33C	78	2N1303/4/5	
PF34A	74	2N1307/8	65
2N1613	30	2SC1061	250
2N1671B	160	2SC1096	85
2N2160	295	2SC1162	30
2N2219A/20A/		2SC1172	125
21A/22A	25	2SC1173	125
2N2369A	18	2SC1306	100
2N2646	45	2SC1307	150
2N2846	80	2SC1449	85
2N2904A/05A/		2SC1679	190
06A/07A	20	2SC1678	140
2N2926G	10	2SC1923	50
2N3053	26	2SC1945	225
2N3054	58	2SC1953	90
2N3055	48	2SC1957	90
2N3442	140	2SC1969	140
2N3614	199	2SC2028	85
2N3615	199	2SC2029	200
2N3702/3	10	2SC2078	170
2N3704/5	10	2SC2091	85
2N3706/7	10	2SC2166	165
2N3708/9	10	2SC2314	85
2N3710	10	2SC2465	125
2N3771	179	2SC2547	30
2N3772	195	2SD234	75
2N3773	210	2SK45	90
2N3819	22	2SK288	225
2N3820	38	2SJ83	225
2N3822/3	45	2SJ85	225
2N3866	90	3N128	112
2N3903/4	15	3N140	112
2N3906/5	15	40097	120
2N4069	45	40100	215
2N4427	80	40101	130
2N4859	78	40250	95
2N4871	55	40251	150
2N5135/6	20	40311	60
2N5172	18	40313	130
2N5179	45	40315	90
2N5180	45	40316	95
2N5191	75	40317/20	80
2N5194	80	40360	60
2N5305	24	40361/62	70
2N5457	30	40406/7	75
2N5458/9	30	40408	75
2N5485	36	40411	285
2N5777	45	40412	90
2N6027	32	40467	130
2N6109	60	40468	85
2N6290	70	40594	105
2SA636	250	40595	110
2SA671	250	40603	110
2SA715	60	40673	70
2SC495/6	70	40871/2	90

LINEAR IC's

555 CMOS	80	LM311	55	SAB3271	485	ZN425E-8	345
702	75	LM318	150	SAB4209	595	ZN426E-8	300
709C 8 pin	35	LM319	195	SG3402	295	ZN427E-8	590
710	48	LM324	65	SL490	350	ZN428E	410
741	14	LM334Z	90	SL6270	150	ZN429E-8	210
747C 14 pin	65	LM335	128	SN76013N	350	ZN459	325
748C 8 pin	36	LM339	47	SN76023N	350	ZN1034E	200
753 8 pin	185	LM348	64	SN76033	350	ZN1040E	665
810	159	LM349	115	SN76377	420	ZNA234E	850
8037CJ	850	LM358	60	SN76488	480		
9400CJ	350	LM377	175	SP8629	299		
AY-1-1320	225	LM379	480	TA7120	125	**COMPUTER IC's**	
AY-1-5050	99	LM380	75	TA7130	125		
AY-1-5051	160	LM381N	145	TA7204	195	1702	350
AY-1-6720	210	LM384	115	TA7205	175	1802CP	650
AY-3-1270	675	LM386	90	TA7222	150	2114L-200n	95
AY-3-8910	420	LM387	120	TAA900	395	2147-3	425
AY-3-8912	450	LM389	95	TAB1042	110	2532-3	300
AY-5-1230	450	LM392	60	TBA120S	70	2564	£6
AY-5-1317A	630	LM393	45	TBA540	275	2708	225
CA3011	130	LM394CH	290	TBA550Q	330	2716-5V	225
CA3012	175	LM725CN	325	TBA641	290	2732	350
CA3014	275	LM733	70	TBA651	190	2764	575
CA3018	86	LM2917	195	TBA800	80	3242	590
CA3019	80	LM3900	50	TBA810S	95	4116-150	85
CA3020	210	LM3909	85	TBA820	80	4116-200	80
CA3023	210	LM3911	125	TBA920Q	200	4118-250	325
CA3028A	95	LM3914	200	TBA990	350	4164-200	425
CA3035	255	LM3915	200	TCA270	350	4532-3	350
CA3036	270	LM3916	250	TCA280A	220	4816-100ns	215
CA3043	275	LM13600	110	TCA940	175	5101	220
CA3045	365	LS7220	280	TCA965	145	6116-150ns	350
CA3046	70	M51513L	230	TDA1004	290	6116L-120ns	550
CA3048	220	M51515L	320	TDA1008	310	6117-100n	490
CA3059	285	M706B1	125	TDA1010	198	6167-6	795
CA3075	213	MB3712	220	TDA1022	499	6502 CPU	325
CA3080E	70	MB3756	440	TDA1024	115	6503	600
CA3081	190	MC1303	98	TDA1034	350	6504-250	550
CA3086	48	MC1304P	260	TDA1490	350	6520	100
CA3089E	200	MC1310P	150	TDA2002	325	6522 VIA	295
CA3090AQ	375	MC1445	250	TDA2003	198	6530 RRIOT	£11
CA3123	165	MC1455	50	TDA2004	495	6532 RIOT	570
CA3130	90	MC1458	35	TDA2006	330	6545 CRTC	899
CA3140	40	MC1469	300	TDA2020	320	6551 ACIA	650
CA3160	95	MC1494	694	TDA2030	295	6592 PC	£220
CA3161E	160	MC1495	350	TDB0791	420	68B54	780
CA3162E	450	MC1496L	70	TL061CP	40	6800	220
CA3189	200	MC1596	225	TL062CP	60	6802	250
CA3240	110	MC1648	290	TL064CN	98	6803	850
HA1366	175	MC1709G	90	TL071CP	24	6804	160
HA1388	255	MC3302	90	TL072CP	45	6805	670
ICL7106	690	MC3340P	120	TL074CN	100	6808	520
ICL7107	975	MC3360P	120	TL081CP	24	6809	630
ICL7204	550	MC3401	65	TL082CP	45	6810	115
ICL7611	99	MC3403	75	TL083CP	75	6820	100
ICL7660	248	MC3405	150	TL084CP	90	68B21	220
ICL8038CC	300	MC3423P	80	TL091CP	55	6821	100
ICL8211	350	MF10	350	TL170	50	6840	375
ICM7204	550	MFC6040	75	TL430C	90	6843	00
ICM7205	1150	MK50398	635	TL507	110	6845	650
ICM7207	475	MM5220	235	UA2240	100	6847	650
ICM7215	1050	MM5526	820	UA78540	230	6850	110
ICM7216A	£22	NE515	275	UAA170	180	6852	250
ICM7217A	750	NE529	225	UAA180	180	6854	599
ICM7224	785	NE531	140	UAA1003-3	935	6875	500
ICM7240	300	NE543	225	UGN3020T	160	68000	£78
ICM7555	80	NE544	210	ULN2001	80	74922 New msk	400
ICM7556	150	NE555	16	ULN2003	75	8080A	250
LA3350	220	NE556DB	45	ULN2004	75	8085A	350
LA4031P	240	NE558	140	ULN2068	290	8088	£18
LA4032	295	NE560	325	ULN2802	200	81LS95	80
LA4400	295	NE561	395	ULN2804	150	81LS96	80
LA4422	275	NE562B	410	ULN2283	100	81LS97	80
LC7120	350	NE564	420	UPC575	165	81LS98	85
LC7130	340	NE565A	120	UPC1025H	265	8118-10	225
LC7137	395	NE566	155	UPC1032	95	8123	125
LF347	150	NE567	140	UPC1156H	225	8155	350
LF351	48	NE570	410	UPC1366	195	8156	350
LF353	95	NE571	400	XR2206	300	8202	£25
LF355	85	NE5532	145	XR2207	375	8205	225
LF356	95	NE5534	105	XR2211	575	8212	110
LF357	110	OM335	750	XR2216	675	8214	425
LF398	475	RC4136D	60	XR2266	360	8216	100
LM10	325	RC4558	45	ZN414	80	8224	110
LM301A	24	S566B	225	ZN419CE	180	8226	250
LM307	45	SAB3209	425	ZN423E	130	8228	220
LM308	95	SAB3210	325	ZN424E	130	8243	270
						8250	850

8251A	250	Z80DART	495	74S Series	
8253	400	Z80ADART	550		
8255	225	Z80ADMA	895	74S00	24
8256A	£35	Z80DMA	675	74S02	24
8257A	400	Z80P10	260	74S04	30
8259	395	Z80AP10	275	74S05	60
8271	£28	Z80S10-1	850	74S08	40
8279	385	Z80AS10	900	74S10	40
8282	450			74S11	50
8283	450			74S20	40
8284	350			74S22	40
8285	365			74S30	40
8287	£17			74S32	70
8288	£10			74S37	60
8T26A	99			74S74	75
8T27	150			74S85	295
8T28A	120			74S86	70
8T31	350			74S112	90
8T95N	90			74S113	90
8T97N	90			74S114	90
9364AP	550			74S124	300
9602	220			74S132	110
AM26LS31C	125			74S133	60
AM26LS32A	125			74S138	115
AM26LS33A	125			74S139	115
AY-3-1015	300			74S140	60
AY-5-1013	300			74S151	180
AY-5-1350	388			74S153	182
AY-5-2376	600			74S157	250
AY-5-3600	750			74S158	195
COM8017	275			74S163	300
COM8116	700			74S174	250
DM8131	275			74S175	320
DP8304BN	250			74S188	140
DS3691N	320			74S189	140
DS8820	110			74S194	320
DS8830	110			74S195	480
DS8831	125			74S197	400
DS8832	250			74S201	350
DS88L120N	275			74S225	500
E9365	£38			74S240	300
E9366	£35			74S241	300
FD1761	£15			74S244	290
FD1771	£15			74S251	250
FD1791	£22			74S257	250
FD1793	£23			74S258	250
FD1795	£28			74S260	70
FD1797	£28			74S262	850
HD2650I	75			74S287	225
HMG167-6	795			74S288	150
IM6402	380			74S289	290
INS8060N	1050			74S299	540
INS8154N	£9			74S301	000
MC1488	55			74S365	000
MC1489	55			74S373	400
MC14411	675			74S374	365
MC14412	725			74S470	325
MC3446	250			74S471	620
MC3447P	315			74S472	1150
MC3486	175			74S474	400
MC3487	175			74S475	800
MK3886-2M	£7			74S571	620
MM5280D	695			74S573	950
MM5303	635				
MM5307	1275				
MM5387A	475				
MM58174	700				
RO-3-2513L	650				
RO-3-2513U	600				
SFF96364E	800				
SP0256AL2	£18				
TMS2716-3	725				
TMS6011	365				
TMS4164-15	475				
TMS4416-2	475				
TMS4532-3	350				
TMS9927	£14				
TMS9928	£20				
TMS9929	£16				
TMS5100	£10				
TMS6011	365				
TMS4164-15	475				
ULN2003	75				
UPD7002	425				
Z80CPU 2·5	299				
Z80ACPU4M	300				
Z80CTC	250				
Z80ACTC	260				
Z80B	875				

TTL 74

7400	11	74142	175
7401	11	74143	210
7402	11	74144	210
7403	12	74145	50
7404	13	74147	75
74L04	85	74148	60
7405	15	74150	50
7406	20	74151	40
7407	20	74153	40
7408	14	74154	55
7409	14	74155	40
7410	14	74156	40
7411	16	74157	30
7412	18	74159	80
7413	18	74160	60
7414	20	74161	48
7416	20	74162	40
7417	20	74163	40
7420	15	74164	60
7421	20	74165	48
7422	20	74166	48
7423	20	74167	150
7425	18	74170	125
7426	18	74172	250
7427	18	74173	60
7428	25	74174	54
7430	14	74175	19
7432	20	74176	40
7433	22	74177	45
7437	25	74178	80
7438	22	74179	80
7440	15	74180	40
7441	55	74181	115
7442	32	74182	60
7443	90	74184	90
7444	90	74185	95
7445	55	74186	470
7446	60	74188	250
7447	30	74190	48
7448	40	74191	46
7450	16	74192	46
7451	16	74193	45
7453	16	74194	45
7454	16	74195	40
7460	16	74196	46
7470	30	74197	40
7472	24	74221	54
7473	24	74246	120
7474	20	74247	120
7475	25	74248	120
7476	25	74249	120
7480	40	74251	65
7481	120	74259	150
7482	65	74265	55
7483	38	74273	150
7484	70	74276	120
7485	60	74278	100
7486	28	74279	50
7489	170	74283	50
7490	20	74284	155
7491	35	74285	155
7492	25	74290	105
7493	25	74293	80
7494	35	74297	236
7495	35	74298	100
7496	35	74351	195
7497	90	74365	30
74100	80	74366	30
74104	50	74367	30
74105	55	74368	30
74107	20	74390	75
74109	25	74393	90
74110	35	74490	95
74111	55		
74112	170		
74116	50		
74118	55		
74119	60		
74120	60		
74121	25		
74122	35		
74123	35		
74125	35		
74126	35		
74128	35		
74132	28		
74136	28		
74141	55		

74LS

LS00	11	LS91	36	4013	20
LS01	11	LS92	36	4014	46
LS02	11	LS93	37	4015	40
LS03	12	LS94	33	4016	20
LS04	12	LS95	33	4017	32
LS05	12	LS96	45	4018	45
LS08	12	LS97	45	4019	25
LS09	12	LS98	50	4020	42
LS10	12	LS107	55	4021	40
LS11	12	LS109	22	4022	40
LS12	12	LS112	22	4023	13
LS13	15	LS113	22	4024	32
LS14	26	LS114	22	4025	13
LS15	12	LS122	36	4026	80
LS20	12	LS123	38	4027	20
LS21	12	LS124	90	4028	39
LS22	12	LS125	24	4029	45
LS26	12	LS126	25	4030	15
LS27	12	LS132	35	4031	125
LS28	14	LS133	30	4032	80
LS30	12	LS136	24	4033	125
LS32	13	LS138	25	4034	140
LS33	14	LS139	28	4035	45
LS37	14	LS145	70	4036	275
LS38	15	LS147	100	4037	115
LS40	13	LS148	70	4038	110
LS42	28	LS151	40	4039	290
LS47	35	LS153	40	4040	40
LS48	45	LS154	80	4041	40
LS49	50	LS155	30	4042	40
LS51	14	LS156	36	4043	40
LS54	14	LS157	27	4044	40
LS55	14	LS158	30	4046	105
LS63	120	LS160	32	4047	40
LS73	18	LS161	37	4048	40
LS74	18	LS162	37	4049	25
LS75	20	LS163	37	4050	25
LS76	18	LS164	43	4051	45
LS78	18	LS165	50	4052	60
LS83	36	LS166	52	4053	50
LS85	42	LS168	55	4054	85
LS86	16	LS169	55	4055	85
LS90	24	LS170	70	4056	85
LS91	60	LS173	55	4059	435
LS92	32	LS174	50	4060	45
LS93	23	LS175	40	4061	1195
LS95	40	LS181	90	4062	995
LS96	95	LS183	180	4063	85
LS107	40	LS190	36	4066	24
LS109	23	LS191	36	4067	245
LS112	22	LS192	36	4068	14
LS113	16	LS193	37	4069	13
LS114	22	LS194	33	4070	13
LS122	36	LS195	33	4071	13
LS123	38	LS196	45	4072	13
LS124	90	LS197	45	4073	15
LS125	24	LS221	55	4075	13
LS132	35	LS240	55	4076	50
LS133	30	LS241	55	4077	13
LS136	24	LS242	55	4078	15
LS138	25	LS243	55	4081	13
LS139	28	LS244	50	4082	13
LS145	70	LS245	70	4085	50
LS147	100	LS247	50	4086	60
LS148	70	LS248	55	4089	125
LS151	40	LS249	55	4093	20
LS153	40	LS251	30	4094	70
LS154	80	LS253	32	4095	95
LS155	30	LS257	30	4096	70
LS156	36	LS258	35	4097	190
LS157	27	LS259	55	4098	75
LS158	30	LS260	22	4099	75
LS160	32	LS261	100	4160	95
LS161

SPEAKERS
8Ω, 0·3W, 2″; 2·25″, 2·5″, 3″ 80p
0·3W, 2·5″ 40Ω; 64Ω or 80Ω 80p

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

Noise Diode
Z5J 195

SCR's Thyristors

0·8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

DIAC
ST2 25

BRIDGE RECTIFIERS
(plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18	50

ZENERS
Range: 2V7 to 39V 400mW
8p each
Range: 3V3 to 33V. 1·3W
15p each

VARICAPS

MVAM2	165
BA102	30
BB105B	40
BB106	40

TRIACS

3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	120

SOLDERCON PINS

100	75p
500	370p

OPTO ELECTRONICS

LEDS including Clips

TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 .2″ Red	12
0·2″ Yel, Grn, Amber Rectangular LEDs with two part clip. R, G & Y	29
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0·2″ Flashing LED Red	56
0·2″ Bi colour LEDs Red/Green	65
Green/Yellow	80
0·2″ Tri colour LEDs Red/Green/Yellow	85
0·2″ Red High Bright	59
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	54
TIL38	45
TIL81	82
TIL100	90

7 Segment Displays

TIL321 .5″ C.An	115
TIL322 .5″ C.th	115
DL704 .3″ C.Cth	99
DL707 .3″ C.Anod	99
FND357 or 500	120
.3″ Green C.A.	140
±1 .3″ Red or Green	150
Bargraph 10 seg. Red	225
Bargraph NSM3914	500

FERRIC CHLORIDE
Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip 90p

0·5″ LIQUID CRYSTAL DISPLAYS

3½ digit	495
4 digit	530
6 digit	625
BPX25	195
BPW21	295
BPX65	270
IL74	45
ILD74	99
ILQ74	185
TIL111	75
OCP71	120
ORP12	78
2N5777	45
4N33	135
Pin diode	510

OPTO SWITCH
Reflective
TIL139 170
Slotted similar to RS 186

ALUM. BOXES

4×2½×2″	85
4×2¾×2½″	103
4×4×2½″	120
5×4×2	105
5×2¾×1½″	90
5×2¾×2½″	130
5×4×1½″	99
5×4×2½″	120
6×4×2″	120
6×4×3″	150
7×5×3″	180
8×6×3″	210
10×4½×3″	240
10×7×3″	275
12×5×3″	260
12×8×3″	295

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided	SRBP
6″×6″	90p	110p	95p
6″×12″	150p	195p	

VEROBOARDS 0·1″

	Clad	Plain
2½×3¾″	85p	—
2½×5″	100p	—
3¾×3¾″	100p	—
3¾×5″	115p	85p
3¾×17″	390p	275p
4¾×18″	495p	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

'VQ' Board	180
'DIP' Board	374
Vero Strip	144
S100 Board	£14

PROTO-DECs

Veroblock	405
S-Dec	350
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool 350p
Spare Wire (Spool) 75p; Combs 6p ea.
Wire Wrapping Stakes 100 250p

VOLTAGE REGULATORS

1A	T0220 Plastic Casing +ve		−ve	
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		
100mA	T092 Plastic Casing			
5V	78L05	30p	79L05	60p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248	LM317K	320
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	580	LM323K	500
78HG+5 to +24V 5A	599	LM337T	175
		LM723	35
79HG −2.25V to −24V 5A	685	TBA625B	75
LM309K	135	RC4194	375
		RC4195	160

SWITCHES

SLIDE 250V

1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

PUSH BUTTON Spring loaded
Latching or Momentary 6A

SPDT c/over	99
DPDT c/over	145

MINIATURE Non Locking

Push to make	15p
Push break	25p

TOGGLE 2A 250V

SPST	33
DPDT	44
4 pole on off	54

SUB-MIN TOGGLE 2 amp

SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

★ SPECIAL OFFER ★

1 MEGABYTE DRIVES

Mitsubishi Slim Line, Uncased, Double track, Double density, 5¼″. Track Density 96TPI. track to track. Access time: 3mSec. **Only £255.**

ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way 45p

ROTARY: Mains 250V AC, 4 Amp 64p

DIL SWITCHES: (SPST) 4 way **65p;** 6 way **80p;** 8 way **87p;** 10 way **135p;** (SPDT) 4 way **190p.**

THUMBWHEEL Mini front mounting

Decade Switch Module	220p
B.C.D. Switch Module	275p
Mounting Cheeks (pair)	75p

PROXIMITY Switch with magnet 125p

DIL SOCKETS

	Low profile	Wire wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

ZIF DIL SOCKET

16 way	475p
24 way	575p
28 way	850p
40 way	975p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
40	195p	218p

RIBBON CABLE (price per foot)

Ways	Grey	Colour
10	15p	28p
16	25p	40p
20	30p	50p
26	40p	65p
34	60p	85p
40	70p	90p
64	100p	135p

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	160p	220p	310p
FEMALE				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS	90p	80p	80p	90p

IDC 25 way Plg. **385p,** Skt. **450p**

SIL Sockets 0.1″
20 way **65p**
32 way **95p**

EDGE CONNECTORS

	.1″	.156″
2×10 way	—	135p
2×15 way	—	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	170p	190p
2×25 way	225p	220p
2×28 way	210p	—
2×30 way	245p	—
2×36 way	295p	—
2×40 way	315p	—
2×43 way	395p	—
2×75 way	550p	—

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2 rows	PCB Male with latch Strt. Pins	PCB Male with latch Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	195p
20 way	145p	166p	125p	240p
26 way	175p	200p	150p	320p
34 way	205p	236p	169p	340p
40 way	220p	250p	190p	420p
50 way	235p	270p	200p	470p

EURO CONNECTORS

	FEMALE SOCKETS Strt.	FEMALE SOCKETS Angle	MALE PLUGS Strt.	MALE PLUGS Angle
DIN 41617 31 way			170p	175p
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2-3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA 98p
6VA: 2x6V-5A; 2x9V-4A; 2x12V-0·3A; 2x15V-25A 220p
12VA: 2x4V5-1·3A; 2x6V-1·2A; 2x12V-5A; 2x15V-4A 295p (35p p&p)
24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-8A 15-8A; 20V-6A 20V-6A 330p (60p p&p)
50VA: 2×6V-4A; 2×9V-2·5A; 2×12V-2A; 2×15V-1·5A; 2×20V-1·2A; 2×25V-2A; 2×30V-0·8A 465p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2·5A; 2×30V-1·5A; 2×40V-1·25A; 2×50V-1A 920p (60p p&p)

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DIL Plug (Headers)
Single Ended Lead, 24″ long

Length	14pin	16pin	24 pin	40 pin
24″	145p	165p	240p	325p
Double Ended Leads				
6″	185p	205p	300p	465p
12″	198p	215p	315p	490p
24″	210p	235p	345p	540p
36″	230p	250p	375p	595p

IDC FEMALE RECEPTACLE Jumper Leads 24″

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

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	IDC	Solder
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1·8MHz	395
1·8432M	200
2·0MHz	225
2·4576M	200
2·5MHz	225
2·56250M	220
3·2768M	150
3·57954M	98
3·6864M	300
4·0MHz	150
4·032MHz	290
4·194304M	290
4·433619M	100
4·608MHz	200
4·80MHz	200
5·0MHz	160
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	150
6·5536MHz	200
7·0MHz	150
7·168MHz	250
7·68MHz	200
8·0MHz	150
8·08333M	395
8·867237M	175
9·00MHz	200
9·375MHz	350
10·0MHz	175
10·5MHz	250
10·7MHz	150
10·24MHz	200
12·0MHz	175
12·528MHz	300
14·31818M	170
14·7456M	175
14·765MHz	250
15·0MHz	200
16·0MHz	200
18·0MHz	180
18·432M	150
19·968MHz	150
20·0MHz	200
24·0MHz	170
24·930MHz	325
29·695MHz	150
26·670MHz	325
27·125MHz	295
27·145M	190
27·648MHz	300
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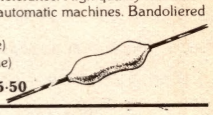

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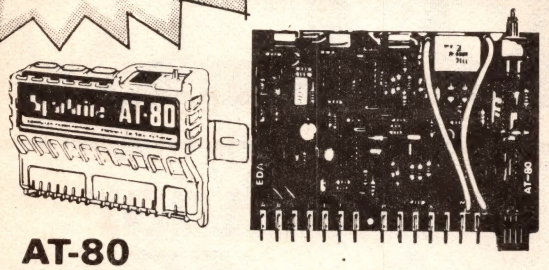

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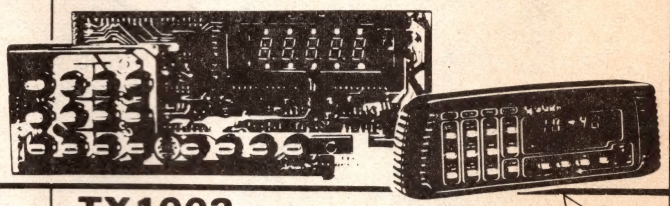

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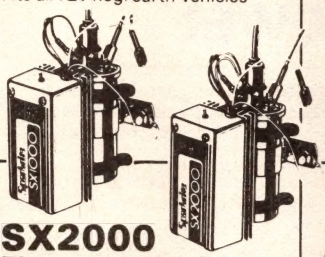

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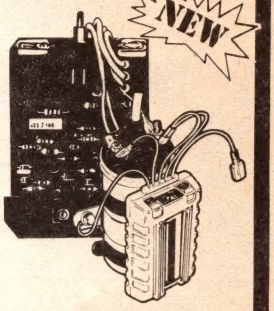

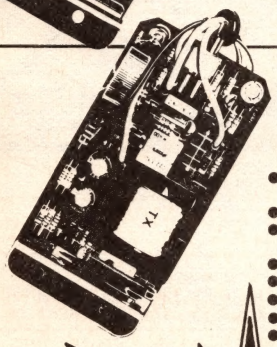

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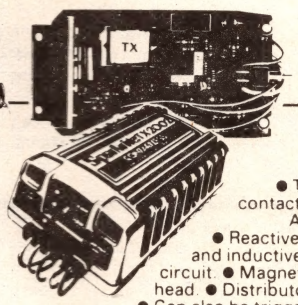

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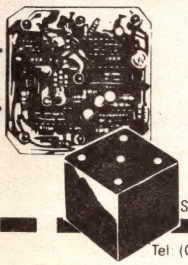

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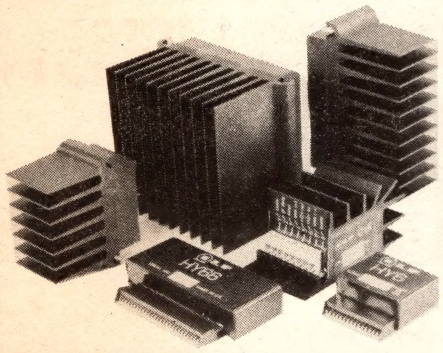

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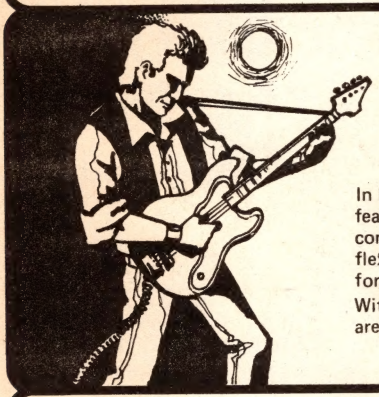

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HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
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HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

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Module Number	Module	Functions	Current Required	Price inc. VAT
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HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

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PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for **110V**, "1" in place of X for **220V**, and "2" in place of X for **240V**.

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (–3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz > 400.

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C15
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.
Very easy to use.
Robust construction. **£9.14 (inc. VAT)**
Mounts anywhere in car.
Automatic switch on.
Output power maximum 22w peak into 4Ω
Frequency response (–3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm. Weight 256 gms.

C1515
Stereo version of C15. **£17.19 (inc. VAT)**
Size 95 x 40 x 80. Weight 410 gms.

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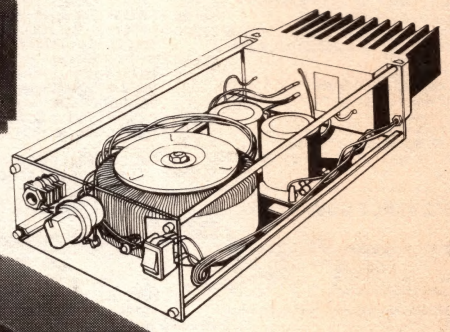

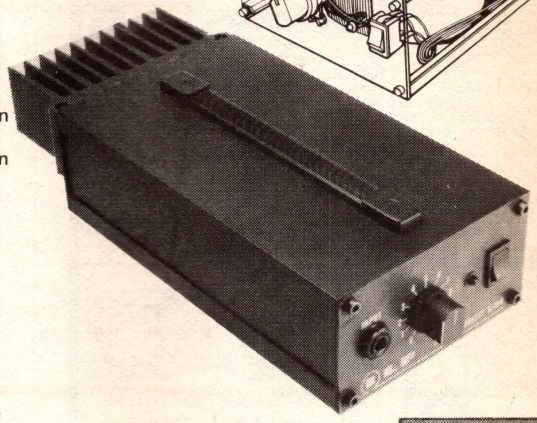

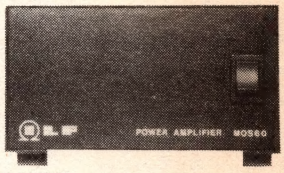

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Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4–8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert '0' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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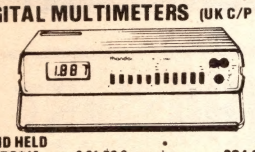

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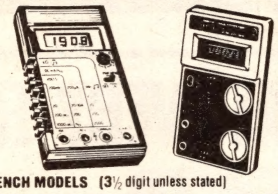
K030C* 26 range 1A AC/DC 20 meg ohm £34.95
K055C* 28 range 10A AC/DC 20 meg ohm £39.95
6010+ 22 range 10A AC/DC 20 meg ohm £34.40
7030+ As 6010 but 0.1% basic. £41.30
188M 16 range 10A DC. 2 meg plus Hfe tester £39.95
189M 30 range 10A AC/DC. 20 meg plus Hfe tester £69.95

HAND HELD AUTO RANGE

DM2350* 21 range 10A AC/DC 20 meg ohm (Miniature) £49.95
HD30 16 range 0.2A AC/DC 2 meg ohm £41.95
HD30/B As above plus cont. buzzer £44.50
HD31 22 range 10 AC/DC 2 meg ohms plus cont. buzzer £58.95



BENCH MODELS (3½ digit unless stated)

TM353* 27 range LCD 2A AC/DC £86.25
TM355* 29 range LED 10A AC/DC £86.25
TM351* 29 range LCD 10A AC/DC £113.85
2001 28 range LCD 10A AC/DC plus 5 range Cap. Meter with case £108.00
TM451 4½ digit LCD every facility (0.02%) £171.00
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1503Ha 0.03% basic version of above £189.00
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8000B 9 digit LED 3 ranges 1 GHZ £178.00
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TF200* 8 digit LCD 200 MHZ £166.75
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TP1000 1 GHZ £74.00

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(220/240v AC)

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TG102 0.2 HZ – 2 MHZ £166.75
PULSE
TG105 Various facilities 5 HZ – 5 MHZ £97.75
AUDIO : Multiband Sine/Square
LAG27 10 HZ to 1 MHZ £86.00
AG202A 20 HZ to 200 KHZ £78.00
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SG402 100 KHZ to 30 MHZ £59.95
LSG17 100 KHZ to 150 MHZ £71.00

AUDIO • RF • FUNCTION • PULSE

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SC110A*. Miniature 10 MHZ battery portable Post free £171.00
HM103 15 MHZ 2mV. 6 x 7 display plus component tester C/P £3.00 £177.00
* Optional carry case £6.84 AC adaptor £6.69
Nicads £12.50
DUAL TRACE (UK C/P £4.00)
HM203/4 Dual 20 MHZ plus component tester £276.00
CS1566A Dual 20 MHZ. All facilities £299.00
HM204 Dual 20 MHZ plus component tester sweep delay. £419.75

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X1 – X10 £10.50 X100 £16.95

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C7081 50K/V 21 ranges. Range doubler 10A DC. SPECIAL PRICE £15.95
ETC5000/5001 21 ranges. 50K/V. Range doubler. 10A DC. £16.50
TMK500 23 ranges 30K/V. 12A DC plus cont. buzzer. £23.95
NH56R 20K/V. 22 range pocket £10.95
EU102 14 range 2K/V pocket £5.95
830A 26 range 30K/V. 10A AC/DC overload protection. etc. £23.95
360TR 23 range 100K/V. Large scale 10A AC/DC plus Hfe £36.95
AT1020 18 range 20K/V. Deluxe plus Hfe tester £17.50
ST303TR 21 range 20K/V plus Hfe tester £16.95

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PP241 0/12/24V. 0/1A. £35.00
PP243 3 amp version £59.95 (UK C/P £1.00)

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(UK C/P 65p)

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µFd	V	
10	16	6p
22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p

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typically +5%
1pF to 10nF 7p

POLYCARB 5% SIEMENS 7.5mm MINI-BLOC E12 250V
1nF to 6n8 7p
8n2 to 47nF 8p
56nF to 150nF 10p
100V
100nF to 150nF 11p
180nF to 270nF 14p
330nF to 390nF 20p
470nF to 560nF 26p
680nF 30p
1µF (10mm) 35p

POLYESTER 250V RADIAL (C280)
10nF, 15nF, 22nF, 33nF, 47nF, 68nF, 100nF 7p
150nF, 220nF 10p
330nF, 470nF 13p
680nF 18p
1µF 22p
1µ5, 2µ2 39p

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3.3/35V 18p
4.7/16V 18p
4.7/35V 20p
6.8/25V 20p
6.8/35V 21p
10/16V 18p
10/35V 27p
15/10V 22p
15/16V 30p
15/25V 32p
22/6.3V 26p
22/16V 29p
33/10V 30p
47/3V 14p
47/6.3V 34p
47/16V 39p
100/13V 32p
100/10V 55p

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Mainly Matsushita (Panasonic) & Siemens
AXIALS (Wires each end)

µFd	V	
.47	63	8p
47	100	9p
47	350	30p
1	63	8p
1	100	9p
1	500	40p
2.2	25	8p
2.2	63	9p

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All 240V Primary
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Bits X25

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SOLDER 125gms

18 swg	2.95
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2N2218	33p
2N2218A	25p
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2N2219A	28p
2N2220	22p
2N2221	22p
2N2221A	23p
2N2222	24p
2N2222A	25p
2N2223	2.60
2N2223A	4.15
2N2368	25p
2N2369	19p
2N2369A	18p
2N2904A	27p
2N2905	28p
2N2905A	29p
2N2906	25p
2N2906A	30p
2N2907	25p
2N2907A	26p
2N2920	3.47
2N2923	25p
2N2924	15p
2N2925	15p
2N2926	10p
2N3053	27p
2N3054	56p
2N3055	60p
2N3055H	120p
2N3250	36p
2N3251	36p
2N3439	98p
2N3440	80p
2N3441	1.25
2N3442	1.35
2N3442RCA	1.85
2N3445	4.80
2N3446	6.09
2N3447	5.72
2N3448	6.56
2N3468	1.00
2N3512	1.06
2N3553	2.30
2N3638	55p
2N3638A	67p
2N3702	10p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	1.38
2N3714	2.98
2N3715	3.31
2N3716	3.60
2N3773	1.99
2N3819	25p
2N3820	38p
2N3821	1.84
2N3822	90p
2N3823	45p
2N3824	1.70
2N3866	90p
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N4030	66p
2N4031	55p
2N4032	65p
2N4036	58p
2N4037	43p
2N4240	3.00
2N4347	2.26
2N4400	15p
2N4401	27p
2N4402	30p
2N4403	30p
2N4409	36p
2N4410	42p
2N4427	79p
2N4870	80p
2N4871	55p
2N4888	92p
2N4901	1.69
2N4902	3.52
2N4903	3.24
2N4904	2.75
2N4905	3.25
2N4906	3.42
2N4907	3.20
2N4908	3.70
2N4909	2.90
2N4918	95p
2N4919	1.28
2N4920	1.34
2N4921	55p
2N4922	69p
2N4923	99p
2N5086	36p
2N5087	39p
2N5088	37p
2N5089	37p
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	79p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
2N5266	2.88
2N5293	98p
2N5294	1.28
2N5295	1.37
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	29p
2N5458	29p
2N5459	29p
2N5460	72p
2N5551	37p
2N5894	5.95
2N5884	5.95
2N6121	54p
2N6122	56p
2N6123	59p
2N6124	56p
2N6125	59p
2N6126	71p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1.14
2N6134	1.36
2N6253	1.45
2N6254	1.55
2SC1306	95p
2SC2078	1.70
2SJ49	3.50
2SJ50	3.75
2SJ82	4.29
2SK134	3.50
2SK135	3.50
2SK226	4.29
3N128	1.12
3N140	2.37
3N200	6.93
3N201	2.98
40360	60p
40361	67p
40362	67p
40363	2.22
40406	1.39
40407	75p
40408	1.58
40410	1.80
40411	2.85
40412	90p
40673	83p
40822	1.80
40871	89p
40872	89p
AC125	35p
AC126	25p
AC127	25p
AC128	25p
AC132	39p
AC141K	28p
AC142K	28p
AC151	51p
AC152	45p
AC153	55p
AC153L	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
AF239	55p
AF240	1.00
AL102	3.49
AU110	2.20
AU113	3.67
BC107	10p
BC107A	12p
BC107B	12p
BC108	10p
BC108A	12p
BC108B	12p
BC108C	14p
BC109	10p
BC109B	12p
BC109C	12p
BC140	29p
BC141	37p
BC142	29p
BC143	34p
BC147	10p
BC147A	10p
BC147B	10p
BC147C	20p
BC148	12p
BC148A	12p
BC148B	13p
BC148C	13p
BC149	10p
BC149B	12p
BC149C	13p
BC152	35p
BC153	23p
BC154	27p
BC157	11p
BC157A	12p
BC157B	13p
BC158	10p
BC158A	12p
BC158B	13p
BC159	11p
BC159A	12p
BC159B	13p
BC159C	18p
BC160	42p
BC161	48p
BC167	10p
BC167A	10p
BC167B	13p
BC168	10p
BC168B	10p
BC168C	10p
BC169	10p
BC169B	10p
BC169C	10p
BC177	16p
BC177A	25p
BC177B	26p
BC178	16p
BC178A	24p
BC178B	25p
BC179	20p
BC179A	25p
BC197B	25p
BC179C	27p
BC182	10p
BC182A	12p
BC182B	13p
BC182L	10p
BC182LA	13p
BC182LB	14p
BC183	10p
BC183A	11p
BC183B	12p
BC183C	13p
BC183L	10p
BC183LA	13p
BC183LB	13p
BC183LC	14p
BC184	10p
BC184B	12p
BC184C	13p
BC184L	10p
BC194LB	13p
BC184LC	14p
BC186	24p
BC187	24p
BC212	10p
BC212A	12p
BC212B	13p
BC212L	10p
BC212LA	13p
BC212LB	14p
BC213	10p
BC213A	11p
BC213B	12p
BC213C	13p
BC213L	10p
BC213LA	13p
BC213LB	13p
BC213LC	14p
BC214	10p
BC214B	12p
BC214C	13p
BC214L	10p
BC214LB	13p
BC214LC	14p
BC237	14p
BC237A	16p
BC237B	17p
BC237C	18p
BC238	14p
BC238A	15p
BC238B	16p
BC238C	17p
BC239	15p
BC239A	16p
BC239B	17p
BC239C	18p
BC300	45p
BC301	44p
BC302	43p
BC303	47p
BC327	14p
BC328	14p
BC337	15p
BC338	15p
BC440	32p
BC441	33p
BC460	32p
BC461	33p
BC516	40p
BC517	40p
BC547	13p
BC547A	14p
BC547B	14p
BC548	12p
BC548A	13p
BC548B	14p
BC548C	15p
BC549	13p
BC549B	14p
BC549C	15p
BC550	30p
BC550C	33p
BC557	15p
BC557A	16p
BC557B	16p
BC558	14p
BC558A	15p
BC558B	16p
BC558C	17p
BC559	15p
BC559B	16p
BC559C	17p
BC560	32p
BC560C	34p
BC660	45p
BC651	66p
BCY70	16p
BCY71	16p
BCY72	19p
BD131	44p
BD132	44p
BD135	40p
BD136	40p
BD137	42p
BD138	39p
BD139	39p
BD140	39p
BD237	98p
BD238	96p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD243C	85p
BD244A	82p
BD244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BD249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1.32
BD712	1.32
BDX14	1.30
BDX18	1.59
BDX32	3.47
BDY54	1.70
BDY55	1.75
BDY56	1.80
BDY57	5.25
BDY58	6.15
BF194	12p
BF195	12p
BF196	12p
BF197	12p
BF198	15p
BF199	15p
BF200	1.49
BF224J	32p
BF225J	35p
BF240	38p
BF241	38p
BF244A	35p
BF244B	39p
BF245A	30p
BF245B	51p
BF246	52p
BF246A	39p
BF246B	53p
BF247A	54p
BF247B	55p
BF254	39p
BF255	42p
BF256A	35p
BF256B	48p
BF256C	62p
BF257	30p
BF258	32p
BF259	35p
BF457	46p
BF458	58p
BF459	62p
BF469	85p
BF470	85p
BF479	25p
BF480	25p
BF494	25p
BF495	25p
BF679	25p
BF680	25p
BF681	25p
BFR90	2.11
BFS28	2.95
BFS98	1.50
BFS98	1.70
BFX29	26p
BFX30	27p
BFY50	23p
BFY51	23p
BFY52	23p
BFY53	31p
BSX19	24p
BSX20	24p
BSX21	40p
BU104	2.22
BU105	1.70
BU108	2.95
BU109	3.29
BU126	1.47
BU204	2.25
BU205	1.75
BU206	1.89
BU208	1.98
BU226	3.25
BU326S	2.35
BU406	1.45
BU407	1.45
BU408	1.35
BU500	2.95
BUY18S	3.95

E430 5.95
J300 48p
J310 53p
MJ802 3.99
MJ900 2.90
MJ901 3.10
MJ1000 2.50
MJ1001 3.00
MJ1800 3.60
MJ2500 2.19
MJ2501 2.25
MJ2955 1.00
MJ3000 2.19
MJ3001 2.25
MJ4502 3.99
MJ15003 4.85
MJ15004 5.55
MJ15015 2.45
MJ15016 3.34
MJE340 53p
MJE350 1.50
MJE2955 99p
MJE3055 69p
MPSA05 23p
MPSA06 25p
MPSA10 28p
MPSA12 29p
MPSA13 48p
MPSA14 46p
MPSA16 30p
MPSA18 65p
MPSA20 48p
MPSA42 49p
MPSA43 49p
MPSA55 28p
MPSA56 30p
MPSA65 40p
MPSA66 47p
MPSA70 45p
MPSA92 39p
MPSA93 39p
MPSL01 42p
MPSL51 48p
MPSU01 84p
MPSU04 1.32
MPSU05 55p
MPSU06 56p
MPSU07 75p
MPSU51 88p
MPSU55 58p
MPSU56 59p
MPSU57 1.20
OC20 2.30
OC25 2.50
OC28 1.70
OC29 2.35
OC35 2.35
OC43 70p
OC44 82p
OC70 50p
OC71 50p
OC72 50p
OC82 50p
OC83 75p
TIP29A 32p
TIP29C 38p
TIP30A 35p
TIP30C 38p
TIP31A 38p
TIP31C 39p
TIP32A 38p
TIP32C 42p
TIP33A 65p
TIP33C 78p
TIP34A 74p
TIP34C 88p
TIP35A 1.09
TIP35C 1.28
TIP36A 1.29
TIP36C 1.39
TIP41A 49p
TIP41C 55p
TIP42A 55p
TIP42C 65p
TIP49 1.20
TIP50 1.40
TIP53 1.57
TIP54 1.58
TIP110 74p
TIP112 90p
TIP115 81p
TIP117 96p
TIP120 69p
TIP122 73p
TIP125 84p
TIP127 84p
TIP130 93p
TIP132 93p
TIP135 99p
TIP137 99p
TIP140 1.04
TIP142 1.04
TIP145 1.15
TIP147 1.15
TIP162 4.95
TIP2955 77p
TIP3055 70p
TIS43 40p
TIS88A 62p
VN10KM 60p
VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 10p
ZTX300 13p
ZTX301 15p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 35p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 35p
ZTX330 35p
ZTX341 28p
ZTX450 39p
ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 34p
ZTX530 24p
ZTX531 25p
ZTX650 45p

DIODES

1N34A 30p
1N821 70p
1N823 92p
1N914 8p
1N916 10p
1N4001 4p
1N4002 4½p
1N4003 5½p
1N4004 5½p
1N4005 6p
1N4006 6½p
1N4007 7p
1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N5400 12p
1N5401 13p
1N5402 14p
1N5403 15p
1N5404 18p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
IS44 10p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA155 15p
BA156 38p
BA157 25p
BA158 30p
BA159 32p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAX13 10p
BAX16 11p
BY126 20p
BY127 22p
BY134 52p
BY182 1.26
BY206 36p
BY207 36p
BY223 1.56
BY297 48p
BY299 55p
MZ2361 1.80
OA47 20p
OA90 10p
OA91 10p
OA95 20p
OA200 20p
OA202 20p

SCRs, TRIACS, DIACS

THYRISTORS
4, 8 & 12 Amps
Texas TO220
Suffice: A = 100V
B = 200V
C = 300V
D = 400V
M = 600V

TIC106A 46p
TIC106B 47p
TIC106D 48p
4A TIC106D 49p
TIC106M 68p
TIC116A 66p
TIC116B 68p
8A TIC116C 71p
TIC116D 73p
TIC116M 80p
TIC126A 72p
TIC126B 72p
2A TIC126C 73p
TIC126D 77p
TIC126M 95p

TRIACS
Texas 400V
TO220 Case
TIC206D(4A) 66p
TIC225D(6A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11

DIACS

BR100	40p
ST2	25p

ZENER DIODES

400·500mW
E24 Series
2.4·47V 7p
1.3 Watt
E24 Series
3.3·82V 14p

BRIDGE RECTIFIERS

(PIV shown in brackets)
1½ amp type
W01 (100) 20p
W02 (200) 26p
W04 (400) 28p
W08 (800) 40p
2 amp type
Square with hole
S01 (100) 37p
S02 (200) 40p
S04 (400) 40p
S08 (800) 55p
6 amp type
Square with hole
PW01 (100) 50p
PW02 (200) 78p
PW04 (400) 85p
PW06 (600) 90p
25 amp type
Metal clad with hole
K01 (100) 2.20
K02 (200) 2.30
K04 (400) 2.80
K06 (600) 3.40

OPTO

LEDs
R = Red
G = Green
Y = Yellow

Large diffused	1 -	50 +
R5D	9p	7p
G5D	15p	12p
Y5D	15p	12p
Small diffused		
R2D	8p	6p
G2D	12p	10p
Y2D	12p	10p

Micro 0.1"

R1D	25p	22p
G1D	27p	25p
Y1D	27p	25p

Large clear

R5C	12p	10p
G5C	17p	13p
Y5C	17p	13p

Super bright high efficiency 70p
Large (100 times brighter)

R5U	38p	29p
G5U	42p	34p
Y5U	42p	34p

Rectangular
Stackables LEDs
R6L 17p
G6L 18p
Y6L 19p

LINEAR ICs

AY1-5050 95p
AY3-8910 5.39
AY3-8912 5.59
CA3048 2.99
CA3059 2.80
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 39p
CA3140T 95p
HA1366W 2.40
HA1388 1.75
ICL7106 7.50
ICL7107 9.75
ICL7611 97p
ICL7660 1.95
ICL8038 2.95
ICL7555 80p
ICL7556 1.50
LC7120 3.20
LC7130 3.20
LC7137 3.85
LF347 1.40
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.09
LF398 4.59
LM335Z 1.19
LM348N 62p
LM349N 1.16
LM350K 4.60
LM379S 4.50
LM380N14 75p
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.12
LM383T 3.40
LM384N 1.40
LM386 88p
LM388N 2.43
LM391N60 70p
LM391N80 1.93
LM723CH 1.21
LM723CN 40p
LM725CH 3.40
LM725CN 3.19
LM741CH 69p
LM741CN 96p
LM747CN 15p
LM748CH 69p
LM748CN 1.00
LM1871 35p
LM1872 4.39
LM1886 4.38
LM1889 2.44
LM2907N 3.77
LM2907N8 2.75
LM2917N 2.60
LM2917N 1.89
LM3900 1.89
LM3911 49p
LM3914 2.00
LM3915 2.00
LM3916 2.50
LM13600 1.10
OM335 7.20
NE531N 1.36
NE543N 2.50
NE544N 1.80
NE555 16p
NE556 45p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 3.75
NE571 3.75
NE5534A 95p
PLL02A 4.95
PLL03A 12.75
RC4136 59p
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.75
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TCA910 2.19
TCA940 1.99
TDA1002 3.39
TDA1003 3.94
TDA1004 2.87
TDA1005 3.94
TDA1010A 2.25
TDA1022 4.95
TDA1024 1.19
TDA2610 3.90
TDA2611A 2.50
UAA170 1.59
UAA180 1.69
ULN2003 85p
UPC575C2 2.50
UPC1156 2.75
XR2206 2.92
ZN414 79p
ZN419 1.90
ZN1034 1.90
ZN1040 6.75

74 TTL

7400 11p
7401 11p
7402 11p
7403 12p
7404 12p
7405 15p
7406 16p
7407 16p
7408 14p
7409 14p
7410 15p
7411 16p
7412 14p
7413 16p
7414 17p
7417 17p
7420 15p
7421 20p
7422 20p
7423 20p
7425 18p
7426 18p
7427 18p
7428 18p
7430 14p
7432 17p
7433 21p
7437 19p
7438 19p
7440 15p
7441 65p
7442 27p
7443 65p
7444 65p
7445 46p
7446 50p
7447 35p
7448 40p
7450 15p
7451 15p
7453 15p
7454 14p
7460 15p
7470 30p
7472 25p
7473 23p
7474 18p
7475 22p
7476 24p
7480 40p
7481 1.19
7482 63p
7483 38p
7484 63p
7485 60p
7486 18p
7489 1.70
7490 20p
7491 35p
7492 25p
7493 34p
7494 24p
7495 34p
7496 34p
7497 85p
74100 80p
74104 50p
74105 55p
74107 20p
74109 25p
74110 29p
74116 50p
74118 53p
74119 57p
74120 80p
74121 25p
74122 30p
74123 34p
74125 30p
74126 29p
74128 35p
74132 38p
74136 27p
74141 55p
74142 1.75
74143 1.95
74144 1.95
74145 38p
74147 89p
74148 55p
74150 49p
74151 35p
74153 35p
74154 49p
74155 40p
74156 40p
74157 30p
74159 75p
74160 40p
74161 40p
74162 40p
74163 40p
74164 40p
74165 40p
74166 48p
74170 1.17
74172 2.50
74173 48p
74174 54p
74175 49p
74176 39p
74177 45p
74178 68p
74180 40p
74181 1.15
74182 55p
74184 90p
74185 90p
74186 4.69
74188 2.50
74190 45p
74191 45p
74192 45p
74193 45p
74194 40p
74195 40p
74196 40p
74197 48p
74198 77p
74199 77p
74221 53p

74LS TTL

74LS00 11p
74LS01 11p
74LS02 11p
74LS03 12p
74LS04 12p
74LS05 12p
74LS08 12p
74LS10 12p
74LS11 12p
74LS12 12p
74LS13 19p
74LS14 22p
74LS15 14p
74LS20 12p
74LS21 12p
74LS22 12p
74LS27 12p
74LS28 14p
74LS30 12p
74LS32 13p
74LS33 14p
74LS37 14p
74LS38 14p
74LS40 12p
74LS42 28p
74LS47 35p
74LS51 14p
74LS54 14p
74LS55 14p
74LS73 18p
74LS74 18p
74LS75 18p
74LS76 18p
74LS78 18p
74LS80 1.20
74LS83 33p
74LS85 39p
74LS86 16p
74LS90 22p
74LS92 25p
74LS93 24p
74LS95 36p
74LS96 50p
74LS107 20p
74LS109 23p
74LS112 20p
74LS113 22p
74LS114 22p
74LS122 25p
74LS123 34p
74LS124 89p
74LS125 24p
74LS126 25p
74LS132 33p
74LS136 24p
74LS138 24p
74LS139 27p
74LS145 70p
74LS147 99p
74LS148 69p
74LS151 30p
74LS153 39p
74LS154 79p
74LS155 29p
74LS156 36p
74LS157 27p
74LS158 28p
74LS160 32p
74LS161 35p
74LS162 35p
74LS163 35p
74LS164 40p
74LS165 50p
74LS168 84p
74LS169 85p
74LS170 70p
74LS173 55p
74LS174 39p
74LS175 39p
74LS181 88p
74LS183 1.20
74LS190 36p
74LS191 36p
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74LS194 32p
74LS195 32p
74LS196 45p
74LS197 48p
74LS221 50p
74LS240 55p
74LS241 56p
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74LS247 50p
74LS248 55p
74LS249 55p
74LS251 30p
74LS253 32p
74LS257 29p
74LS258 33p
74LS259 55p
74LS261 99p
74LS266 18p
74LS273 53p
74LS275 1.25
74LS279 30p
74LS280 95p
74LS283 40p
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74LS290 45p
74LS293 40p
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74LS298 79p
74LS299 1.55
74LS323 1.55
74LS324 1.45
74LS325 2.96
74LS326 2.30
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74LS348 88p
74LS352 7.25
74LS353 79p
74LS362 7.25
74LS365 29p
74LS366 29p
74LS367 29p
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74LS373 59p
74LS378 58p
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4002 11p
4006 49p
4007 15p
4008 32p
4009 24p
4010 24p
4011 10p
4012 15p
4013 20p
4014 46p
4015 39p
4016 20p
4017 32p
4018 44p
4019 25p
4020 44p
4021 39p
4022 39p
4023 12p
4024 32p
4025 12p
4026 77p
4027 20p
4028 37p
4029 43p
4030 14p
4031 1.19
4032 80p
4033 1.20
4034 1.29
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(hand-held model)

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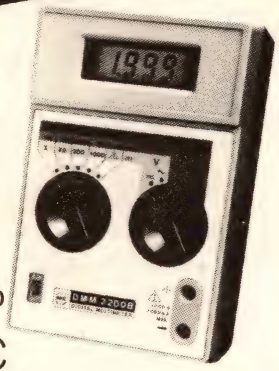

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SINCLAIR AND ORIC COMPUTERS

UK prices are shown first. The bracketed prices are export prices which inlcude insured air-mail postage to all the countries of Europe including Norway, Sweden, Findland and Denmark. For overseas customers outside Europe an extra £5 postage per item is charged. Oric 1 48K Computer **£147 (£158).** ZX81 **£43.43 (£52).** ZX Printer **£52.13 (£61).** ZX Spectrum **£108.70 (£129).** ZX Spectrum 48K **£152 (£172).** 32K Memory Upgrade for 16K Spectrum (Issue 2 only) **£44 (£45).** ZX Microdrive n/a **(n/a).** ZX RS232 n/a **(n/a).** 5 Printer Rolla **£10.43 (£16).** ZX81 Ram Packs:– 16K **£26.04 (£28),** 32K **£39 (£41),** 56K **£49 (£51).**

DRAGON 32 £173

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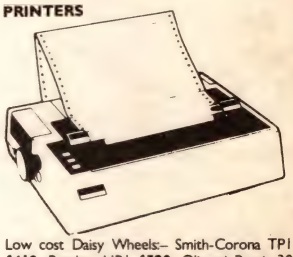

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These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w. of lighting.

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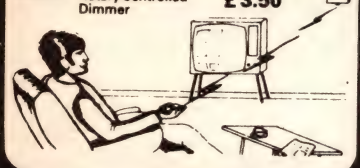
MK6	Transmitter for above	£ 4.20
TD300K	Touchdimmer	£ 7.00
TDE/K	Extension kit for 2-way switching for TD300K	£ 2.00
LD300K	Rotary Controlled Dimmer	£ 3.50



HOME CONTROL CENTRE

This New Remote Control Kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains wiring which are received by receiver modules connected to the same mains supply and used to switch on the appliance addressed. Receivers are addressed by means of a 16-way keyboard, followed by an on or off command. Since pushing buttons can become rather boring, the transmitter also includes a computer interface so you can programme your favourite micro to switch lights, heating, electric blanket, make your coffee in the morning, etc., without rewiring your house. JUST THINK OF THE POSSIBILITIES. The KIT includes all PCBs and components for one transmitter and two receivers, plus a drilled box for the transmitter.
Order as XK112. £42.00
Additional Recievers XK111 £10.00

ELECTRONIC LOCK KIT XK101

This KIT contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to construct a Digital Lock, requiring a 4-key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-wired plug. Size: 7 x 6 x 3 cms. Supply: 5V to 15 V d.c. at 40uA. Ouput: 750mA max. Hundreds of uses for doors and garages, car anti-theft device, electronic equipment, etc. Will drive most relays direct. Full instructions supplied.
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MINI KITS

MK1 TEMPERATURE CONTROLLER/THERMOSTAT
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MK2 Solid State Relay
Ideal for switching motors, lights, heaters, etc. from logic. Opto-isolated with zero voltage switching. Supplied without triac **£2.60**

MK3 BAR/DOT DISPLAY
Displays an analogue voltage on a linear 10 element LED display as a bar or single dot. Ideal for thermometers, level indicators, etc. May be stacked to obtain 20 to 100 element displays. Requires 5-20V supply. **£4.50**

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Based on the SL441 zero voltage switch, this kit may be wired to form a "burst fire" power controller, enabling the temperature of an enclosure to be maintained to within 0.5°C. Max. load 3KW **£5.55**

MK5 MAINS TIMER
Based on the ZN1034E Timer IC this kit will switch a mains load on (or off) for a preset time from 20 mins. to 35 hrs. Longer or shorter periods may be realised by minor component changes. Max. load 1KW. **£5.00**

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Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK102 **£5.00**

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Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. **£5.00**

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PACK 3 60 Polyester Capacitors 0.01 to 1µF/250V — 5 per value **£5.55**
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16 ranges including DC voltage (200 mv-1000v) and AC voltage, DC current (200 mA-10A) and resistance (0-2 M) + NPN & PNP transistor gain and diode check. Input impedance 10M. Size 155 × 88 × 31mm. Requires PP3 9V battery. Test leads included. **£29.00**

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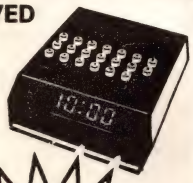
Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it—the clock will do the rest.



FEATURES INCLUDE:-
- 0.5" LED 12 hour display.
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(Kit includes all components, PCB, assembly and programming instructions). ORDER AS CT5000

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DL 1000K
This value-for-money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. **£14.60**

DLZ100K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum.
Optional opto input DLA1 Allowing audio ("beat") — light response. **Only £8.00 60p**

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The XK103 is a general purpose infra-red transmitter/receiver with one momentary (normally open) relay contact and two latched transistor output. Designed primarily for controlling motorised garage doors and two auxillary outputs for drive/garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons.
The Kit comprises a mains powered receiver, a four button transmitter, complete with pre-drilled box, requiring a 9V battery and one opto-isolated solid state switch kit for interfacing the receiver to mains appliances. As with all our kits, full instructions are supplied.
ONLY £23.75

REMOTE CONTROL KITS

MK6 SIMPLE INFRA RED TRANSMITTER
Pulsed infra red source complete with hand-held plastic box. Requires a 9V battery. **£4.20**

MK7 INFRA RED RECEIVER
Single channel, range approx. 20ft. Mains powered with a triac output to switch loads up to 500W at 240V ac. **£9.00** (RC500K –Special Price for MK6 and MK7 together **£12.50**

MK8 CODED INFRA RED TRANSMITTER
Based on the SL490, the kit includes all components to make a coded transmitter and only requires a 9V (PP3) battery and keyboard. 8 x 2 x 1.3cms **£5.90**

MK10 16-WAY KEYBOARD
For use with MK8 and MK18 to generate 16 different codes for decoding by the ML928 or ML926 receiver (MK12) kit. **£5.40**

MK11 10-Channel + 3 Analogue o/p IR Receiver
Based on ML922 decoder IC. Functions include on/standby output, toggle, control of volume, tone and lamp brightness. Includes its own mains supply. **£12.00**

MK12 16-CHANNEL IR RECEIVER
For use with MK8 kit with 16 on/off outputs, which with further interface circuitry, such as relays or triacs, will switch up to 16 items of equipment on or off remotely. Latched or momentary outputs – please specify when ordering. Includes its own mains supply. **£11.95**

MK13 11-WAY KEYBOARD For use with MK8, MK18 and MK11 kits. **£4.35**

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For use with MK6 or MK16. Relay output with DP 3 Amp change-over contacts, may be used as latched, momentary or "break beam" receiver. Operates from 6-13V d.c. **£9.50**

MK18 HIGH POWER IR TRANSMITTER
Similar to MK8 but with range of approx. 60ft. **£6.20**

Ancillary Kits : MK2 Solid State Relay
Opto-isolated with zero voltage switching. No. triac supplied. **£2.60**

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises 2 x solid state relays and latch for use with momentary version of the MK12. 2 output triacs required (not supplied). **£4.50**

24 HOUR CLOCK/APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at present times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

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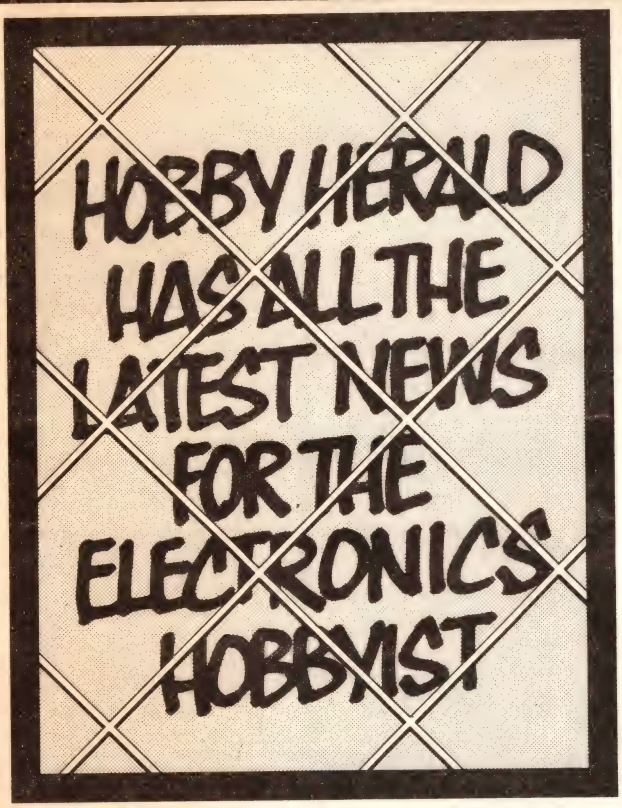

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STORM EFFECTS: Automatic & manual wind, rain & surf generator	SET 154	£16.72
SYNTHESISER INTERFACE: allows instrument to trigger synth functions	SET 81	£9.49
TREMOLO: Deep tremolo with depth & rate controls	SET 136	£10.71
TREBLE BOOST: Increases volume of upper octaves	SET 138-T	£8.46
TONE CONTROL: bass & treble cut, gain & range (6 controls)	SET 139	£13.62
VIBRATO: variable rate & depth plus additional phasing	SET 137	£23.99
VODALEK: Robot type voice modulator with depth & rate controls	SET-155-LS	£12.40
VOICE FILTER: Tunable for selected freq bandwidth & gain	SET 142	£9.69
VOICE-OP-FADER: for reduction of music level during talk-over	SET 30	£9.85
VOICE-OP-SWITCH: with variable sensitivity & delay, 1A 2PCO relay	SET 123-LS	£13.80
WAH-WAH: with auto-trigger, manual & oscillator control	SET 140	£17.31
WHEEBY-JEEBY: 2 intercoupled oscillators produce variable sirens	SET 151	£13.78
WIND & RAIN: manual control of these two effects	SET 28	£11.39
WOBBLE-WAH: Oscillator controlled wah-wah for fascinating effects	SET 161	£13.40

KIMBER ALLEN KEYBOARDS (surely the best?):	3-Oct **£32.43**, 4-Oct **£40.68**, 5-Oct **£48.52**
KEYBOARD CONTACTS GJ (SPCO):	3-Oct **£20.29**, 4-Oct **£26.50**, 5-Oct **£32.71**
KEYBOARD CONTACTS GB (DPST):	3-Oct **£23.27**, 4-Oct **£30.45**, 5-Oct **£37.62**

PHONOSONICS

PHONOSONICS MAIL ORDER, DEPT PE3/5, 22 HIGH STREET, SIDCUP, KENT DA14 6EH, 01-302 6184

Please use full address. Payment CWO, CHQ, PO, ACCESS, BARCLAY, or pre-arranged collection. Prices incl. UK P&P & 15% VAT. E&OE. Despatch usually 7 days on most items. Details of parts in above kits are stated in our comprehensive catalogue. Send S.A.E. (9×4 or bigger) for Catalogue (if you live overseas please send £1.00 or equiv). MORE KITS ARE IN CATALOGUE.

ELECTROVALUE

- 24 HOUR NORMAL DESPATCH TIME
- ESTABLISHED 1965
- ALL GOODS GUARANTEED BRAND NEW AND TO SPECIFICATION
- APPOINTED SIEMENS DISTRIBUTORS

I.Cs – DIGITAL & ANALOGUE

DIGITAL

74LS

74LS00	11
74LS02	11
74LS04	12
74LS05	12
74LS08	12
74LS10	12
74LS11	12
74LS14	25
74LS20	13
74LS30	12
74LS32	13
74LS37	14
74LS38	14
74LS42	28
74LS47	36
74LS51	14
74LS73	18
74LS74	16
74LS75	18
74LS76	15
74LS85	40
74LS86	16
74LS90	22
74LS92	30
74LS93	22
74LS107	20
74LS112	20
74LS123	34
74LS125	24
74LS126	25
74LS132	34
74LS136	23
74LS137	90
74LS138	25
74LS139	27
74LS145	70
74LS148	75
74LS151	40
74LS153	40
74LS155	30
74LS156	36
74LS157	27
74LS161	36
74LS163	36
74LS164	30
74LS165	50
74LS166	60
74LS173	55
74LS174	45
74LS175	40
74LS191	36
74LS193	40
74LS195	39
74LS196	48
74LS197	60
74LS221	48
74LS240	55
74LS241	55
74LS242	55
74LS243	55
74LS244	55
74LS245	70
74LS251	30
74LS253	30
74LS257	30
74LS259	55
74LS266	20
74LS273	55
74LS279	30
74LS299	150
74LS367	30
74LS368	28
74LS373	60
74LS374	55
74LS378	60
74LS393	45
7400	
7400	11
7401	11
7402	11
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	14
7410	14
7413	18
7414	20
7420	15
7430	14
7440	14
7442	32
7443	60
7444	60
7447	36
7448	40
7450	14
7451	14
7453	14
7454	14
7460	14
7470	24
7472	24
7473	26
7474	20
7475	25
7476	25
7480	35
7482	65
7483	38
7485	60
7486	18
7489	159
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	34
74100	80
74104	45
74107	20
74121	24
74123	34
74125	29
74126	29
74141	52
74151	30
74154	50
74155	39
74156	35
74157	30
74190	45
74191	45
74192	45
74193	45
74393	78

CMOS

4000	10
4001	10
4002	12
4006	50
4007	14
4008	32
4009	24
4010	24
4011	11
4012	16
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	39
4023	14
4024	32
4025	13
4026	80
4027	20
4028	39
4029	45
4030	15
4041	40
4042	40
4043	40
4044	40
4046	46
4049	23
4050	23
4060	45
4069	13
4070	13
4071	13
4072	13
4081	13
4082	13
4093	20
4510	45
4511	45
4514	110
4516	53
4518	40
4520	50
4543	75
4583	90

All above prices are NET and shown in pence

ANALOGUE

709C5	49
709C14	44
723C14	36
741C5	57
741C8	16
741C8/S	56
741C14	47
747C14	65
748C8	35
741S	56
1458C5	62
1458C14	40
7106	450
7107	500N
555	18N
7555	80N
556	45
CA3046	70N
CA3080E	80N
CA3130E	90N
CA3140E	45N
LM301AN	25N
LM308N	60
LM317K	295
LM324N	32
LM348N	65
LM380N	66
LM380N8	80
LM381N	145
LM382N	115
LM3900N	50
LM3914N	250
LM3915N	200
NE555V	18N
NE556A	45
NE567N	104
RC4151NB	80
S041E	290
S041P	121
S042E	364
S042P	138
S89	11.23
S178A	16.60
S187	11.95
S566B	214
S576A	235
S576B	235
S576C	235
S576D	225
S1469	468
SAB0600	302
SAB3209	425
SAB3210	311
SAB3211	168
SAB3271	329
SAB4209	497
SAB8256C	35.40
SAD1024	9.00N
SAJ131	238
SAJ141	278
SAJ205	810
SAS231W	260
SAS251	142
SAS580	198
SAS590	196
SDA5680A	15.55
TAA761	104
TAA761A	49
TAA765A	62
TAA861	103
TAA865A	59
TAA2761A	72
TAA4761A	113
TAA4765A	120
TAB1041K	187
TBA120AS	62
TBA120U	72
TBA800	75
TBA10S	75
TBA820	75
TBB1458	62
TBB1458B	40
TCA105	120
TCA105B	108
TCA105G	140
TCA250A	185
TCA205K	200
TCA335A	66
TCA345A	109
TCA345W	177
TCA671	131
TCA780	211
TCA871	114
TCA955	228
TCA965	120
TCA965K	170
TCA971	92
TCA991	80
TCA991K	100
TDA2002	120
TDA2003	126
TDA2030	150
TDA4050B	144
TDA4290	169
TDA4600	184
TDA4700A	546
TDA4713A	435
TFA1001W	252
TL071CP	25N
TL072CP	45N
TL074CN	100N
TL081CP	25N
UAA170	165
UAA170L	152
UAA180	165
UAA190	141
XR2206	300N
ZN414	80
ZN424P	99
ZN425E	350

CRYSTALS

(in MHz)			
0.032768	102	4.433	128
0.100000	453	4.915	157
1.000	453	5.026	128
1.8432	320	6.000	157
2.000	268	6.144	157
2.4576	268	6.5536	128
3.2768	188	8.000	1.88
3.579	128	8.867	128
4.000	102	10.000	157
4.194	128	18.432	188

ZENER DIODES

400mW/2.7-30V	7p
1-3W/3.3-100V	15p
20W/7.5-75V	£1.98

CONNECTORS

DIN AUDIO

Pins	plug	skt
2	8p	8p
3	14p	8p
4	17p	14p
5 (180)	17p	11p
5 (240)	20p	8p
6	18p	20p
7	19p	30p

JACK PLUGS SKTS

MONO

chrome	P1 53p	34p	42p
plastic	P2 32p	14p	20p

STEREO

chrome	P3 81p		52p
plastic	P4 60p	15p	20p

MONO

3.5mm	18p	14p	8
Stereo	23p	42p	

D – SERIES

	Plug	skt	hood
9	64p	96p	92p
15	88p	140p	96p
25	128p	205p	110p
37	176p	298p	122p

IDC Connectors

DIL	
14 way	103p
16 way	117p
24 way	170p
40 way	265p

PARALLEL TYPE

	plug	skt
16 way	1.10	1.30
20 way	1.25	1.45
26 way	1.50	1.70
34 way	1.65	1.95
40 way	1.85	2.10

Plugs have retainers Sockets have strain relief

IC SOCKETS

Pins	Each	25 for
8	6	120N
14	8	160N
16	9	180N
18	11	220N
20	12	240N
22	14	280N
24	15	300N
28	18	360N
40	25	500N

REGULATORS

7805	40	7905	50	7818	40	7918	50
7806	40	7906	50	7824	40	7924	50
7808	40	7908	50	78L05	32	79L05	50
7812	40	7912	50	78L12	32	79L12	50
7815	40	7915	50	78L15	32	79L15	50
				78L24	32	79L24	50

ELECTROLYTICS

1/63	9	1000/10	19
2.2/25	13	1000/16	26
2.2/63	9	1000/25	36
4.7/63	9	1000/40	44
4.7/100	14	1000/63	76
6.8/40	9	2200/6	9
10/6	8	2200/16	44
10/25	9	2200/25	60
10/40	11	2200/40	73
10/63	12	4700/16	72
10/100	15	4700/25	90
22/10	9	**TANTALUM BEADS**	
22/25	11		
22/40	12	0.1/35	13
22/63	15	0.22/35	13
22/100	16	0.47/35	13
47/3	2	1.0/35	13
47/10	11	2.2/16	13
47/25	10	2.2/35	16
47/40	15	4.7/16	16
47/63	17	4.7/35	16
47/100	18	6.8/16	16
100/3	2	6.8/25	24
100/10	12	10/6.3	16
100/16	12	10/16	18
100/25	12	10/25	18
100/40	15	22/6.3	18
100/63	20	22/16	30
100/100	27	22/25	30
220/10	16	33/6.3	24
220/16	16	33/10	30
220/25	16	47/6.3	30
220/40	20	100/3	30
220/28	28	100/10	66
220/100	42		
470/10	19		
470/16	19		
470/25	19		
470/40	27		
470/63	35		
470/100	73		

For full ranges of very many other types please see Cat 82 and/or current price list.

CAPACITORS

Polystyrene, Siemens
5% Tolerance 160V
5, 7, 10, 12, 15, 18, 22, 27, 33, 39pF **15p**: 47, 56, 68, 82, 100,120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 1n, 1n2, 1n5, 1n8, 2n2, 2n7, 3n3, 3n9, 4n7, **10p**: 5n6, 6n8, 8n2, 10n, 15n.
Ceramic. Very small 1.8, 2.2, 2.7 etc. up to 1n **5p each**. 1n5, 2n2, 3n3, 4n7, 6n8, **5p**: 10n, 22n, **6p**: 33n, 47, **7p**: 68n, 100n, **8p**.
Polyester Siemens Layer Type 7.5mm lead spacing 100V.
1n, 1n5, 2n2, 3n3, **6p**: 4n7, 6n8 **6p**: 8n2, 10n, 12n, 15n, 18n, 22n, 33n, 47n, **7p**: 56n, 68n, **7p**: 82n, 100n, **9p**: 120n, 150n, **11p**: 180n, 220n, **12p**: 270n, 330n, 390n, 470n, **15p**: 560n, 680n, **24p**: 10mm spacing 1uF **25p**: 15mm spacing 2u2 **35p**: 22.5mm spacing 1uF 400V **56p**: 3.33uF 100V **69p**: In depth stocks.

BOXES

High quality Black ABS plastic or die-cast plain or stove grey.

L	W	D	ABS		Plain		Stove Gr	
50	50	25	–		5001P	90p	5001	123p
100	60	25	2002	96p	5002P	117p	5002	154p
113	63	31	2003	109p	5003P	143p	5003	184p
121	66	40	2004	115p	5004P	162p	5004	210p
152	82	50	2005	134p	5005P	216p	5005	268p
192	113	61	2006	235p	5006P	314p	5006	401p

VERO RANGE plastic boxes

L	W	D		
72	47	25	21024	54p
120	50	35	21390	87p
180	110	55	21391	160p

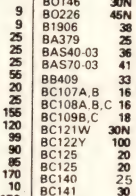
G RANGE professional Instrument Cases

134	90	44	21089	£7.68
224	140	64	21090	£11.62
302	170	84	21091	£15.78

VEROBOX CASES

to give a completely professional finish to a much valued project.
ABS, light grey top; dark grey bottom + 2 anodised panels

L	D	H	TYPE	PRICE
205	140	40	21034	£4.52
205	140	75	21035	£5.02
205	140	110	21036	£6.54
180	120	39	21037	£4.11
180	120	65	21038	£4.40
180	120	90	21039	£4.69
155	85	39	21040	£3.31
155	85	60	21041	£3.31
155	85	80	21042	£4.30
125	65	30	21047	£2.48
125	65	39	21048	£3.15
125	65	50	21049	£3.56



METERS

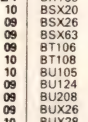
Large range of types in stock; also probes, leads, accessories, etc.
PANEL MOUNTING in 50, 100, 500μA; 1, 5, 10, 50, 100, 500mA; 1A either model.

MU Range 50 × 45mm **£2.68**

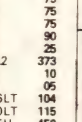
T Range 60 × 45mm **£5.95**

MULTIMETERS

NH56A NEW – 20kΩ/V AC/DC/ RES/dB in 23 ranges: 130 × 88 × 37mm **£11.20N**



YN360TR 20kΩ/V AC/DC/R/ dB/Transistor Test: in 21 ranges: 145 × 96 × 45mm **£16.45N**



SEMICONDUCTORS

1N914	03	2N3819	22	AA118	9	BB105B	32p
1N914B	10	2N3820	40	AA119	9	BB204	57p
1N916	05	3823	60	AC126	25	BO146	30N
1N4007	06	2N3904	15	AC127	25	BO226	45N
1N4148	03	2N3906	15	AC128	25	B1906	38
1N5402	14	2N4036	46	AC151R	55	BA379	25
1N5407	18	2N4058-62	09	AC153K	20	BAS40-03	36
2N697	23	2N4124	25	AC176	25	BAS70-03	41
2N706	18	2N4126	25	ACY17	155	BB409	33
2N930	20	2N4284	30	ACY18	120	BC107A,B	16
2N1132	23	2N4286	18	ACY19	99	BC108A,B,C	16
2N1302	110	2N4289	23	ACY20	90	BC109B,C	18
2N1303	58	2N4291	24	ACY21	85	BC121W	30N
2N1304	62	2N4292	21	ACY39	170	BC122Y	100
2N1305	62	2N4991	62	ACY41	10	BC125	20
2N1306	90	2N5062	32	AD136	150	BC125	20
2N1307	67	2N5192	110	AD142	90	BC140	25
2N1308	147	2N5195	106	AD149	88	BC141	30
2N1309	99	2N5457	32	AD161	35	BC147A	10
2N1599	100	2N5458	32	AD162	35	BC149	10
2N1613	25	2N5459	36	AF114	37	BC154	25
2N1711	25	2N6050	380	AF115	37	BC160	25
2N1893	32	2N6057	375	AF116	57	BC161	30
2N2218A	31	6F40	152	AF117	64	BC167A	09
2N2219A	25	16F40	165	AF124 AF125	37	BC167B	09
2N2222A	25	40HF40	225	AF126	37	BC168A	09
2N2369A	21	40362	65	AF127	37	BC168B	09
2N2484	25	40406	71	AF200	10	BC169B	09
2N2646	46	40408	95	AF239	114	BC169C	09
2N2904	28	40412	108	AF279	30	BC177B	16
2N2904A	25	40430	100	AFY12	204N	BC178B	16
2N2905A	25	40594	123	AFY16	327N	BC179B	18
2N3053	23	40595	123	AFY18D	310N	BC182	09
2N3054	56	40636	147	AFY18E	615N	BC182L	09
2N3055	48	40673	145	AFY42	461N	BC183	09
2N3405	64	A9903	16	AU106	240	BC183L	09
2N3663	15	AA113	13	AU111	(use	BC184	09
3702-11	09	AA116	9	AU116)		BC184L	09
2N3771	180	AA117	13	AUY22	10.95	BC202Y	120
2N3794	21			BO140	25N	BC212	09
						BC212L	09
						BC213	09
						BC213L	09
						BC214	09
						BC214L	09
						BC238C	09
						BC239C	09
						BC258B	09
						BC267B	16
						BC300	32
						BC301	24
						BC303	30
						BC327	16
						BC328	11
						BC337	14
						BC338	11
						BC413	09
						BC414	09
						BC477	24
						BC546	10
						BC547	09
						BC548	09
						BC549	09
						BC550	10
						BC556	10
						BC557	09
						BC558	09
						BC559	09
						BC560	10
						BC879	38
						BC880	43
						BCY31A	157
						BCY58	18
						BCY70	18
						BCY71	18
						BCY72	18
						BD130	45N
						BD131	48
						BD132	48
						BD135	27
						BD136	27
						BD139	30
						BD140	32
						BD644	42N
						BD679	62
						BD680	64
						BF115	35
						BF167	25
						BF173	25
						BF177	25
						BF178	25
						BF244B	40
						BF254	14
						BF255	14
						BF420	31
						BF421	34
						BF457	35
						BF458	35
						BF459	35
						BF597	12N
						BFR34A	84
						BFR39-41	23
						BFR79-81	23
						BFT65	119
						BFT66	192
						BFX29	24
						BFX84	24
						BFX85	24
						BFX87	28
						BFX88	26
						BFY50	24
						BFY51	24
						BFY52	24
						BFY90	143
						BR34	70
						BR64	110
						BRY39	45
						BSX20	22
						BSX26	22
						BSX63	160
						BT106	147
						BT108	136
						BU105	170
						BU124	85
						BU208	180
						BUX26	350N
						BUX28	545
						BUX81	325
						BUX85	130
						BUZ10A	478
						BUZ15	12.27
						BUZ20	523
						BUZ23	787
						BUZ24	12.50
						BUZ32	625
						BUZ33	944
						BUZ41A	637
						BUZ44A	9.67
						BUZ45	12.76
						BUZ48	18.94
						BUZ50A	763
						BUZ54A	12.50
						BUZ80	739
						BUZ83	11.29
						BUZ83A	11.95
						BUZ84A	12.75
						BY164	48
						C106D1	45
						C0326	460N4
						C0340	490N4
						C407	17
						C0546	126N1
						C762	40
						C1406	77
						D4 clip	for
						C1406	and
						E2506	10
						D1046	88
						E1110	76
						E1210	76
						E2506	154
						EB383	20
						MJ2955	90
						MJE340	55
						MJE2955	95
						MJE3055	70
						MPF102	40
						MPS6531	40
						MPS6534	42
						MPSA12	36
						MPSA63	38
						NAS206S5	81
						OA47	12
						OA202	14
						OC28	75
						OC29	75
						OC35	75
						OC36	90
						OC84	25
						PM7A2	373
						PN70	10
						PN72	05
						Q4006LT	104
						Q4010LT	115
						Q4025H	450
						T2700D	189
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						TAG3-400	100
						TAG209-400	85
						TAG209-600	130
						TIC106D	48
						TIC106M	55
						TIC126D	64
						TIC206D	54
						TIC226D	61
						TIC236D	96
						TIC246D	105
						TIP31A	36
						TIP32A	36
						TIP41A	45
						TIP41C	60
						TIP42A	45
						TIP42C	60
						TIP150	75
						TIP2955	55
						TIP3055	55
						TIS43	50
						U763	50
						VN10KM	55
						VN46AF	93
						VN66AF	105
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green	16
Mountings, B65	3

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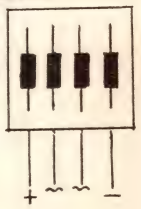

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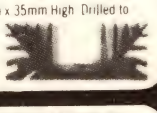

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PE VOLUME 19 No. 5 MAY 1983

PE EDUCATION

THE DoI recognises the value of PE projects in the educational environment! Well that might be a bit strong, but it is a fact that the Department of Industry is proposing a scheme to give robots to schools. In this country there are three companies making suitable small robots and now two of them, Powertran Cybernetics and Colne Robotics, have been involved with publication of robot designs in this magazine. In fact we have now published four designs for robots available from Powertran.

PE's commitment to education goes without saying and just as we were at the forefront of microprocessor learning and the development of personal computing, with publication of the UK101, we are also keeping up the pressure with a continuing involvement in robotics. This issue carries the first part of the highly educational project Zeaker, designed by David Buckley and for which Colne Robotics will be marketing kits.

BASIC PRINCIPLES

The schemes to give school children hands on experience, first of computers and now possibly of robots, are to be applauded but we begin to wonder if in its haste to help youngsters the Government is not failing to teach the technology behind these developments—electronics. It's all very grand to educate our youngsters to be aware of developments, to be able to use them and to appreciate the benefits they bring, but much of the wealth of industrial countries is based on the development and production of these very items that can assist the industrial world. We must never become so reliant on developments that we forget the basic principles of electronics on which they are built.

It is perhaps time to encourage the teaching of electronics in the way we now do computing lest this fundamental is trodden underfoot in the rush to keep up with the new developments it spawns. Computing and robotics are interesting and exciting but many PE readers can vouch that the experience is heightened by construction and understanding of the equipment in use. Such deep involvement in the tool being used also leads to new ideas and to the ability to fully understand limitations and develop ways to overcome them by basic design.

INNOVATION

We must make sure our country continues in the field at which it is best—innovative design in every area. Our software engineers are achieving a worldwide reputation for excellence, Clive Sinclair's achievements need no underlining and we are up with the rest in development of robots. We must not throw all this away by simply teaching our children how to use these tools and not providing them with sufficient basic knowledge of electronics and engineering to make them want to invent and develop the next generations of hardware.

Computers are not blessed with innovative thinking, they can only help achieve an end product from the basic ideas. One thing you can be sure of, PE will continue to thrive on ideas of a fundamental nature—even if these fundamentals do get overlooked elsewhere from time to time. We will also continue to employ these ideas in the design of equipment which is applicable to modern systems, be they computers, robots or whatever else comes along.

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Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

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...news &

Clef Products...
Kits-Update Information

It is not always clear from the advertising that when specialist Kit Suppliers make a long term commitment to PE projects they are able to capitalise on constructor feedback to make modifications in specification or ease of construction. Some of these changes can be very minor but add considerably to the value of the final unit. This is particularly true of Clef Products who have recently provided the following update information on three of their popular musical projects.

MASTER RHYTHM: The facility to vary both tone colour and level of the instruments in this fully programmable Drum-Machine is one of the factors which continue to make the PE Master Rhythm very competitive with any of the commercial units available today. This feature has been extended by incorporating access holes, with identification, into the bottom of the case to give rapid E.Q. for varying situations and musical requirements. Following publication of the PE Bandbox a 7 pin DIN socket was fitted to the front of the Master Rhythm to link the two units and to provide external connection of start, stop, clock, programmed pulse etc., to give sequencer drive and footswitch operation. The complete Master Rhythm Kit incorporates both these changes and costs £79.

BANDBOX: The heart of this unique *"Backing Band"* is a 6502 based Microcontroller, which has allowed specification improvements to be developed purely in software, i.e. by relatively cheap replacement of the Monitor EPROM integrated circuit. Existing customers are notified when a new facility becomes available and around 80% take advantage of the offer to part exchange the old EPROM, at a cost of around ten pounds.

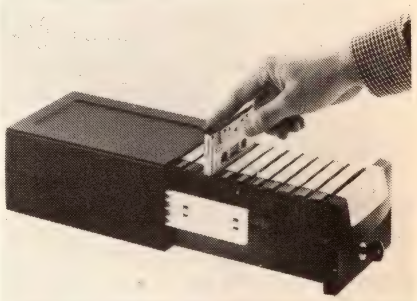
MICROSYNTH: Allan Bradford, the designer of the Microsynth, had made various models of his basic concept, up to four octave compass, and in conjunction with Clef it was decided to adopt a 30 note format as the standard for the Kit. Apart from the musical advantage, this allowed the p.c.b. to be extended in length to include the power supply giving a single board construction. At the same time the front panel layout was then able to accommodate the overall level control and preset adjustments for Line and Headphone outputs. Finally a Keyswitch similar to the principle used in the Clef Electronic Piano range was included giving a further simplification of construction.

Full details on the above can be obtained from Clef Products (Electronics) Ltd., 44A Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH. 061-439 3297.

CASSETTE FILING SYSTEM

For those of us who like things neat and tidy here's a drawer system for storage of cassettes. The Fischer C Box Drawer Unit is an easily accessible storage facility for data tapes containing long term information or games etc.

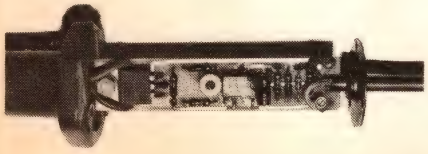
The cassette rests in a spring loaded box that opens at the touch of a button and incorporates splined hubs to prevent slackening of the tapes. There are ten individual boxes with easy change labels housed in each drawer unit, which can be stacked at the user's convenience.



Two designs are available: standard and deluxe (lockable) at £17·50 and £19·50 respectively inc VAT and p&p. Artur Fischer (UK) Ltd, 25 Newtown Road, Marlow, Bucks, SL7 1JY (06284 72882).

LITESOLD Soldering Systems

Litesold have modified their LE40 24 volt in-handle electronically controlled iron, to incorporate proportional band temperature control. Power to the heating element is only fully on or off outside a narrow temperature band centred on the set value. Within this proportional control band, power is supplied in regular pulses of equal interval, but of a length which varies according to the difference between the 'actual' and 'set' temperatures. At the set temperature, 'on' and 'off' periods are equal. Below this temperature the 'on' periods become progressively longer, and above it, progressively shorter, until the limits of the proportional band are reached, when power is continuously on or off. This feature provides much improved control, without temperature swing or overshoot.



External access is provided to the temperature adjustment, which can be set to any value between approximately 280–420°C. Temperature stability around the set point is typically within ±2°C.

The iron is available complete with a power unit for £58·50 inc. VAT.

Litesold have also recently introduced a complete soldering/de-soldering kit for the electronics hobbyist. The kit is centred around a high efficiency 18 watt mains iron, constructed to latest electrical standards, and fitted with a 3·2mm copper bit. There are also two alternative bits included, of 1·6 and 2·4mm. The kit also includes a 3 metre reel of 18 s.w.g. flux-cored solder, stainless steel tweezers, three double-ended soldering aids and a reel of de-soldering braid. This provides all that is required for soldering and de-soldering on almost any electronics project, and is ideal for beginner or expert. The kit comes in a clear PVC wallet, and is available direct from Litesold at a very special mail order price of £14·55 inclusive of postage and VAT. Light Soldering Developments Limited, 97/99 Gloucester Road, Croydon, Surrey, CR0 2DN. (01-689 0574.)

MARKET PLACE

'SCAMP'

A flexible, automatic manufacturing facility which can machine batches of work in three days where conventional manufacture takes eight weeks, has been built using joint government and industry finance. The facility is flexible in that it can be reprogrammed to carry out virtually any batch turning operation.

The parts (along with their blanks) shown in the photograph, were machined by the FMS (Flexible Manufacturing System) called Scamp. This completely automated production line utilises computer controlled turning, grinding and milling machinery, serviced by 600 Fanuc robots which remove the job pieces from a conveyor belt. The factory is manned by three engineers.

The plant is not in Germany, nor Japan, but here in the UK, and it is claimed to be a first. Scamp was developed and installed by Scamp Systems of Colchester, Essex, the home of Colchester Lathes, whose machines form much of the production line. A complex perpetual conveyor system, based on rollers, incorporates gates for controlling the queueing of work pieces. These pieces are conveyed on, and identified by binary coded pallets. Automatic Vision Orientation fixtures optically observe and

orientate the metal blanks correctly for insertion into cutting machinery. The whole process is under the control of a pair of Systime Series 5000E computers.

Scamp has overcome the majority of machine queueing problems associated with automated production. Department of Industry sponsorship was necessary because of the extremely high capital cost of the installation, which would not amortise itself on purely commercial grounds. However, the cost of robotics and electronics continues to fall, whilst the cost of labour continues to rise. It is the DoI's intention that their support scheme will spawn expertise in readiness for the crossover point.

£1000 REWARD

Yes £1000 has been offered as a reward for the recovery of goods, and apprehension of thieves who stole sound equipment from Aura Sounds Ltd in February. The company based in Purley, Surrey, lost several expensive items, the most important of which was a computer controlled rhythm unit known in the trade as the Wersimatic CX 1. The company who are the sole importers of Wersi Organs in the UK say the thieves could not have stolen a more easily traceable item.

The CX 1 pictured is the only one of its kind in the UK at the moment, and it is virtually a prototype, being one of only ten in the world.

MICRO-PROFESSOR COMPETITION

In our Micro-Professor Competition, readers were invited to place eight features of a microcomputer teaching aid in the order, they considered, warranted the greatest consideration.

Having considered all entries, the judges chose a number of identical attempts listing the following selection as being the best received. 1—C; 2—E; 3—K; 4—A; 5—B; 6—D; 7—L; 8—J.

All tying competitors took part in a postal eliminating contest from which the first prizewinner emerged as Mr. K. Lambert, of Halesowen. Mr. Lambert wins a full Micro-Professor system comprising microcomputer, EPROM programming board, and Speech Synthesiser board.

There were also four second prizewinners who each receive a Micro-Professor MPF-1B microcomputer. These winners are: Mr. D. Brown, Bristol; Mr. E. Radley, Liverpool; Mr. S. Rubie-Todd, Bristol; and Mr. D. Thursby, Sutton.

Our thanks to all who took part, and to Flight Electronics for supplying the prizes.

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Intersil ▸ The ICL 7137 is designed to interface to a l.e.d. display, and consumes only 200µA internally. It gives auto-zero to less than 10µV, zero drift less than 1µV/°C, input bias of 10pA max., and rollover error of less than one count. Ideal for economic load-cell, strain gauge and other bridge sensor measurements. A panel meter may be built using only seven passive components and a display. No overrange hangover or hysteresis effects.

▸ The ICL 7115 is a fast CMOS monolithic 14-bit A/D converter which uses successive approximation. Interfacing to a µP is aided by the use of standard Write and Read cycle timing and control. Interface to 8, 12 or 16 bit systems is possible through byte organised, three-state outputs. Resolution is 0·003%, there are no missing codes, conversion takes 40µs, linearity and gain tempco is 1ppm/°C, 4ppm/°C, power consumption is 60W, and no gain or offset adjustment is necessary (0·006% FS). Intersil Datel (UK) Ltd., Belgrave House, Basing View, Basingstoke, Hants.

RCA ▸ A low consumption BiMOS op amp featuring bandwidth/slew rate programmability, the CA3440 has two stages; a high gain (100dB) front end and a low impedance f.e.t./bipolar output stage. Input circuit features gate-protected PMOS transistors. A phase compensation technique allows stable operation in unity-gain follower configuration.

▸ Ultra high speed, high current rectifier family. Reverse recovery time of the RUR-810 is less then 35ns. Available in TO-220AB packages, they are rated at 8A forward current, with PIV of 200V. RCA Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx.

Burr Brown ▸ A new f.e.t. input TO99 op amp, the OPA 105 requires an input bias of less than 1pA. Guaranteed initial offset of 250µV, with a drift of 2µV/°C.

▸ Two high linearity voltage-to-frequency converters called the VFC62 and VFC320. Output pulse train repetition rate is proportional to Vin. They can also be used to convert a pulse train frequency back into a proportional voltage output! Linearity is ±0·005%. Full scale drift is 50 ppm of FSR/°C. Low noise, precision voltage reference, called the REF101, provides ±10V ±5mV at 10mA, adjustable over ±2%. Noise is 100µV pp. Burr Brown, Cassiobury House, Station Road, Watford WD1 1EA.

...news &

DMM TEMPERATURE SENSOR

Anyone who has access to a digital multimeter can now use it as a versatile wide range temperature measuring instrument using standard type K thermo-couples, by adding the DVM/TC Interface Unit.

This new device has a temperature range of −50°C to +1100°C and incorporates automatic cold junction compensation. Thermocouples are attached through a miniature compensated socket. A basic thermocouple, mating plug and battery are supplied as standard with this instrument. The output of 1mV per degree centigrade is via a 0·75 metre coiled lead fitted with 4mm plugs. Long term stability is excellent and the low battery drain allows it to be used for continuous monitoring if necessary. Since the accuracy is not affected by the output loading (the DMM), it may be alternatively used to interface a low output impedance instrument such as a chart recorder. Priced at £42 including VAT and p&p, this interface unit is available from, Graham Bell Instrumentation, PO Box 230, 39 Derbyshire Lane, Sheffield S8 0TH (0742 582370).

INFRA-RED CONTROLLER

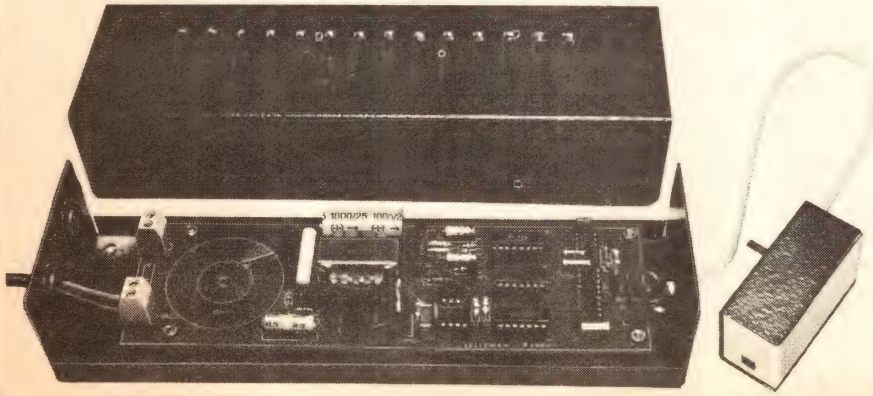
A two channel infra-red (IR) remote controlled light dimmer is now available in kit form, with separate transmitter and receiver units.

The receiver, designed to be controlled by its matching transmitter, gives independent remote on/off and variable control functions. Applications are extremely varied and include the automatic adjustment of both room temperature and lighting. In use, either of the two channels may be assigned to any one receiver, or two identical kits may be assigned to different channels and controlled individually by only one transmitter.

The receiver kit, supplied complete with housing, has a 240Va.c., 50Hz power supply and current consumption is 25mA maximum in the standby mode with a maximum control output of 300 watts. Reaction times from zero to maximum and maximum to zero are 7 seconds, with noise immunity ensured.

The transmitter, designed to operate an IR light dimmer, will control two receivers, with ON/OFF and dim commands. Specifications include bi-phase coded modulation, CMOS technology and power l.e.d. outputs, giving 15 mw/cm² maximum beamed power. Beam deflection is 30° with a reflector and 60° without.

The transmitter is priced at £15 plus VAT and the receiver at £33·60 plus VAT, both items require £1 p&p and are available from, Electronic & Computer Workshop Ltd, 171 Broomfield Rd, Chelmsford, Essex. (0245 62149).



The Open School

Many otherwise mature and competent people are nervous of trying a course in computing. The 'Open Computing School' at South Bank Polytechnic near Waterloo and Elephant and Castle, have developed courses designed to take complete novices to a position where they can design their own useful computer programs. Nor do they have to take a week off or spend a fortune. The Poly believes it is a unique type of service, allowing people who cannot commit themselves to a fixed timetable to work at their own pace, during the day or in the evening. The price is kept low to attract those who are paying their own fees, but the emphasis is on use in administrative work.

A number of managers and employers join in order to get an appreciation of what a microcomputer might do for their organisation, and clerical workers join with the object of improving their career prospects. Other students include engineers, teachers, translators and social service workers. However quite a number of students have no vocational interest but come just because they feel that they ought to keep up with the technological revolution. Some think it will help with the children's homework.

The Open School runs continuously through the college year. Special one-day appreciation courses can be provided for organisations on request. The introductory course costs £45. Write to Polytechnic of the South Bank at Borough Road, London SE1 0AA or Tel. Jack Flatau or Iris Mason on (01-928 8989) ext 2410.

Mobile Satellite

The advantages of having a portable satellite ground station for television are numerous, and the 'Beeb' are paving the way in seeking them out. Their 3M diameter, trailer mounted disc has been on many UK locations since its introduction in 1981. Its first overseas adventure was coverage of the UK team matches in the world cup in Spain last year.

More recently however it was borrowed by the Italian State Television Service for use at the International Slalom Ski event at Bormio, Italy. The ground station was used, from this difficult outside broadcast site, because a terrestrial network would have required five microwave radio links. Pictures of excellent technical quality were transmitted via satellite to the fixed ground station at Milan for local and European distribution. The mobile satellite ground station was built by BBC research engineers at Kingswood Warren in Surrey.

MARKET PLACE

Briefly...

Alone, all alone on the bridge of the Kinokawa Maru, a Japanese 177,000 tonne ore/coal carrier, stands the commander. The ship appears deserted, like the Marie Celeste. The commander talks to himself, seemingly; but the ship answers back with a metallic, synthesised human voice:

"Full Ahead!" resounds the instruction.

"Full Ahead!" echoes the vessel in confirmation.

The engine builds up to full power with no further human involvement.

A handful of years ago this *could* have been the stuff of science fiction, but now it cannot. For fiction it is no longer. The tide of events in technology has lead Sumitomo Heavy Industries to build what they claim to be the first ship in the world which is capable of being manoeuvred at sea by one man.

The Kinokawa Maru is no ordinary ship, for not only is its main engine speed controlled by electronics with voice recognition and synthesis, but it is designed to consume 45% less energy per cargo tonnage. The overall design significantly reduces its owner's fuel costs, whilst sparing its crew a number of chores.

The control system's speech recogniser has a capacity of 40 words, which match the voice pattern of an authorised user. It will ignore all other voices. Its phoneme type synthesiser has a fixed vocabulary of 480 words, and a programmable vocabulary of 1000 words.

With rising transport costs truncating shipping activities worldwide the Japanese look set to stay *full ahead* as a major shipbuilding nation. Each time the Kinokawa Maru puts to sea it leaves in its wake a message for the next generation of ship. To survive the swell of competition, this will need a level of automation that includes remotely controlled auxiliary machinery too, reducing still further the crew's workload—*and the crew!*

● ● ● ●

The Isle of Wight is to be the recipient of Britain's first undersea optical-fibre link. Manufactured by STC at a cost to British Telecom of £600,000, the cable will link Portsmouth with Ryde on the Wight. Due to go into service in 1985, the 23km cable will comprise two 140M bit "bothway" optical systems based on STC's monomode technique, which means that no repeaters will be necessary. The bit rate is equivalent to 1,920 two-way telephone conversations, although the Island's link-up will have the capability to transfer raw data, text and graphics too.

In contrast to the more common 850nm wavelength light source, the Wight connection will use 1300nm lasers. The monomode fibres give rise to less loss and signal scattering than multimode, allowing combined landline and underwater repeaterless transmission.

It is expected that in 1988 an intercontinental optical-fibre link will go into service, a contract for which is to be awarded in November this year.

● ● ● ●

The first Motorola 68000 microprocessor to be made in Europe was produced at East Kilbride, Scotland, in February. The device was produced on their pilot production line at their existing plant; production will be transferred to the new facility (module III) when its construction is complete.

As a 32:16 bit microprocessor it is gaining popularity and is apparently a favourite with software writers, making it the most written for device of its kind. The design team had only one prerequisite in common say Motorola and that was, none of them had been involved in the design of previous older processors.

Aimed at European and Japanese markets (yes Japanese) the 68000 will find its home in systems such as personal computers, business machines, robotics and telecommunications as well as energy and medical fields. Motorola has been producing silicon chips at East Kilbride since 1972.

Countdown . . .

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

Circuit Technology April 18–20. Kensington Ex. Cntr., London. **J2**
All Electronics Show April 19–21. Barbican Cntr., London. **E**
Numerical Control (Ex. & Conf.) April 19–21. Wemb. Conf. Cntr., London **D3**
Fibre Optics April 19–21. Porter Tun Rooms, The Brewery (!) Chiswell St., London EC1. **E**
International Materials Handling April 19–26. Earls Court. **I**
International Packaging Exhibition April 25–29. NEC B/ham. **I**
HEVAC (Heating, Ventilation & Air Cond.) Apr. 26–28. Barbican. **I**
Scottish Personal Computer World Show April 16–18. MacRobert Pavilion, Ingliston, Edinburgh. **M**
Midland Computer Fair April 28–30. Bingley Hall, B/ham. **Z1**
Biotech May 4–6. Wembley. **O**
Micro City May 10–12. Bristol Exhibition Complex. **F3**
The Business Computer Show May 10–12. Wembley. **O**
Cable (Conf. & Ex.) May 10–12. Wembley Conf. Centr., London. **O**
Defence Components Expo May 10–12. Metropole, Brighton. **I**
Compec Scotland May 17–19. Kelvin Hall, Glasgow. **Z1**
Welsh Amateur Radio, TV & Electronics Rally May 22. Barry Memorial Hall, S. Glam. **C**
Computers In The City (conf. & ex.) May 24–26. Barbican. **O**
Business Telecom May 24–26. Barbican. **O**
International Word Processing May 24–27. Wembley Conf. Cntr. **Z**
Motradex May 25–27. Sandown Exhibition Centre, Surrey. **Z1**
East Suffolk Wireless Revival May 29. Ipswich Civil Service Sportsground. **V1**
Russian Holography June–Sept. Inc. Light Fantastic Gallery. **A8**
Semlab June. Olympia. **I**
IBM Productivity (conf. & ex.) June 14–16. Tara Hotel, London. **O**
Tectronica June 14–17. Earls Court. **I**
The Computer Fair June 16–19. Earls Court. **Z1**
Compec North June 21–23. Belle Vue, Manchester. **Z1**
Transducer/Tempcon June 28–30. Wembley Conf. Cntr. **T**
Leeds Electronics Show July 5–7. University. **E**
Electronic Hobbies Fair. The best event ever for the UK electronics hobbyists comes round for the second time from October 27th to 30th at Alexandra Pavilion. Make a date now and watch these pages for EHF news each month. **Z1**

A8	Holographic Exhibitions ✆ 01-826 6423
C	Reg. Rowles ✆ Cardiff 565656
D3	British Numerical Control Soc., London
E	Evan Steadman ✆ 0799 22612
E2	BARTG 89 Linden Gdns., Enfield, Middx.
F	Tomorrow's World Exhibitions, Bristol
I	Industrial Trade Fairs ✆ 021 705 6707
M	Montbuild Exhibitions ✆ 01-486 1951
O	Online ✆ 09274 28211
T	Trident ✆ 0822 4671
Z	BETA Exhibitions ✆ 01-405 6233
Z1	IPC Exhibitions ✆ 01-643 8040

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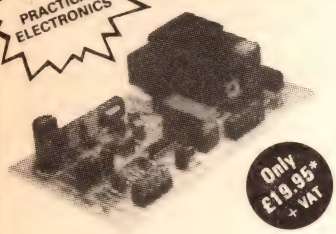

Only £19.95+ + VAT

This exciting new module offers all the possible features likely to be required when building an intruder alarm system. Whether used with only 1 or 2 magnetic switches or in conjunction with several ultrasonic alarm modules or infra-red units, a really effective system can be constructed at a fraction of the cost of comparable ready-made units. Supplied with a fully explanatory Data Sheet that makes installation straight forward, the module is fully tested and guaranteed.
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- Battery back-up with trickle charging facility
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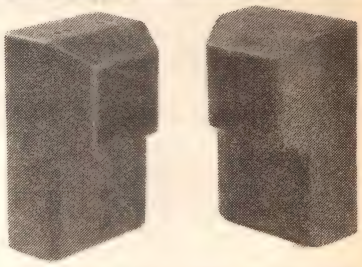
- Separate relay contacts for switching external loads
- Test loop facility

INFRA-RED SYSTEM IR 1470

only £25.61 + VAT



Fully built & tested

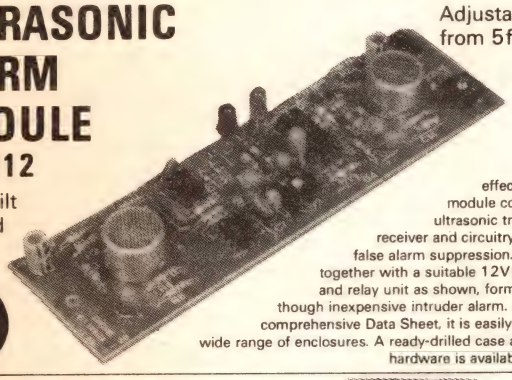
- Range up to 50'
- 12V operation
- Supplied with full instruction
- Easily installed

Now available, a really effective infra-red system built to the high standards demanded by the security industry, and yet offered at this low price. The system consists of a transmitter and receiver which provide an invisible beam over distances from 1-50ft. or more. When the beam is interrupted, a relay is energised in the receiver unit. The use of a modulated beam combined with the infra-red filters, prevent interference from artificial or sunlight, whilst LED indicators ensure easy alignment of the beam. Both units are housed in attractive black moulded enclosures which are easily mounted. Supplied with full instructions, the unit is ideal for use in conjunction with the Control Unit CA 1250 or as an independant unit.

ULTRASONIC ALARM MODULE US 4012

Fully built & tested

Adjustable range from 5ft. to 25ft.



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A really effective fully built module containing both ultrasonic transmitter and receiver and circuitry for providing false alarm suppression. This module, together with a suitable 12V power supply and relay unit as shown, forms an effective though inexpensive intruder alarm. Supplied with comprehensive Data Sheet, it is easily mounted in a wide range of enclosures. A ready-drilled case and necessary hardware is available (see right).

DIGITAL VOLTMETER MODULE DVM 314
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Power Supply & Relay Units PS 4012 £4.25 + VAT

Provides a stabilised 12V output and relay with 3A contacts. The unit is designed to operate one or two of the ultrasonic units. Fully built and tested.

Siren Module SL 157 £2.95 + VAT

Produces a loud and penetrating sliding tone operating from 9-15V. Capable of driving 2 off 8 ohm speakers to SPL of 110db at 2M. Contains an inhibit facility for use with shop lifting loops or other break to activate circuits.

Hardware Kit HW 4012 £4.25 + VAT

A suitable ready-drilled case with the various mounting pillars, mains switch socket and nuts and bolts. Designed to house the ultrasonic alarm module together with its power supply.
Size: 153mm x 120mm x 45mm.

★ ACCESSORIES ★

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PART 2
READOUT INTERFACE BOARD
Digit Talker

A. Wiggin

LAST month the voice synthesis board was described. The board holds a vocabulary of 204 words each of which could be selected by means of a microcomputer or manually operated switches. When used with a computer the vocabulary could be built into sentences, thereby producing an interesting personality for the machine.

There are, however, many applications in which speech is a valuable asset but the expense and sophistication of a microcomputer is not warranted. Such applications are found in the car, home and factory and include speaking the digits on a panel meter or clock, delivering short messages such as INTRUDER AREA ONE, DANGER HIGH PRESSURE etc. or even providing a robust, lightweight alternative to a B.T. teleprinter or VDU.

Until recently, speech could only be reproduced by electro-mechanical systems using magnetic tape or plastic discs. But since the introduction of cheap, reliable large-scale integrated circuits it has become possible to model the human voice using a Linear Predictive Coding algorithm. This algorithm is made up of a random signal generator which forms the basic fricative and plosive sounds, a variable frequency signal generator which is used to produce different pitch sounds and a digital filter which, when configured by a computer in any number of high and low pass, band pass and band stop configurations, moulds the words themselves. The use of the algorithm reduces the minimum amount of memory needed to produce one second of speech from 96,000 bits to 1,100.

VOICE SYNTHESIS BOARD

The basic voice synthesis board consists of a 128K, VM61001 Voice ROM connected to a TMS 5100 Voice Synthesis Processor which in turn drives an audio output stage. A 640kHz clock is produced by RC network which is divided down to give a ROM clock of 160kHz. The 6 control lines which program the board consist of 4 data lines (CTL1-CTL4) and 2 clock lines. All the address data and instructions are loaded via these 6 lines.

Since 18 bits are needed to address one location in a 128K memory, and there are only 4 data lines, then 5 nibbles of 4 bits are loaded sequentially to form each address. Before each nibble is accepted by the processor it must be preceded by a Load Address instruction, thereby commanding the processor to forward the address to the memory over the 4 bit internal bus. The control signal M1 is brought high by the processor during a Load Address instruction which gates the CTL lines directly to the internal bus.

The memory has its own internal register, and can be accessed either in a direct or indirect mode. If, after loading an address, a direct instruction is used, followed by a Test Talk and Speak instruction, then data held in this memory address will be passed to the processor in a serial form via the ADD 8 line of the internal bus. The internal address register will automatically increment, and the processor will request another bit of data by toggling its M0 line. The sequence will repeat until the last series of data instructs the processor to stop.

If, however, a Read and Branch instruction is used, followed by a Speak instruction, then the address loaded via the CTL lines will be taken as the address of the Look-Up table in which is held the address of the start of the data string. The memory then loads the latter address into its register and repeats the above sequence.

The TMS 5100 receives the speech data from the memory and immediately decodes it. The on-board 10 bit A-to-D converter produces an analogue speech signal from this which is then filtered and amplified by the audio output stage.

INTERFACE CIRCUIT

Fig. 2.3 shows a circuit which will produce speech from the voice synthesis board without the use of a microcomputer. The circuit has been designed to be as flexible as possible. Hence it can be operated with or without an EPROM. When the EPROM is inserted into the circuit it will convert coded data, such as that from a 3 digit, 7 segment display (Fig. 2.1), ASC II terminal or even BCD output, to that needed by the voice board. It can be used to multiply the words in a phrase by sequentially switching the inputs of

No	a	b	c	d	e	f	g	Hex	VSB Code
0	1	1	1	1	1	1	0	7E	02
1	0	1	1	0	0	0	0	30	04
2	1	1	0	1	1	0	1	6D	06
3	1	1	1	1	0	0	1	79	08
4	0	1	1	0	0	1	1	33	0A
5	1	0	1	1	0	1	1	5B	0C
6	1	0	1	1	1	1	1	5F	0E
7	1	1	1	0	0	1	0	72	10
8	1	1	1	1	1	1	1	7E	12
9	1	1	1	1	0	1	1	7B	14

Fig. 2.1. Seven-segment digit to VSB code conversion table for EPROM

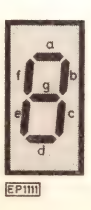
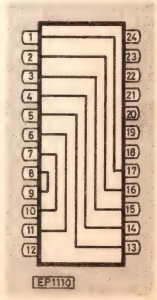


Fig. 2.2. Jumper strip for 2716 EPROM



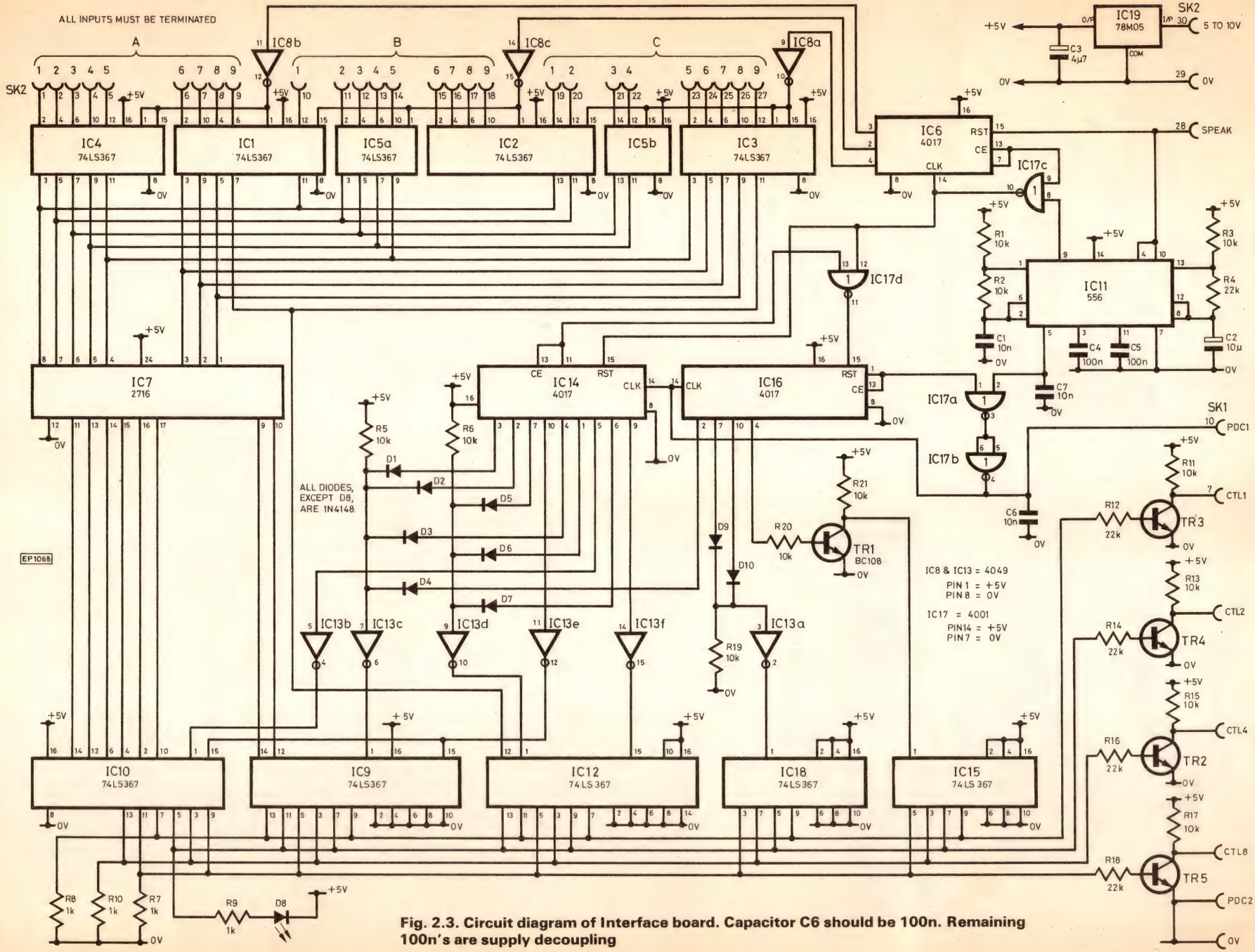


Fig. 2.3. Circuit diagram of Interface board. Capacitor C6 should be 100n. Remaining 100n's are supply decoupling

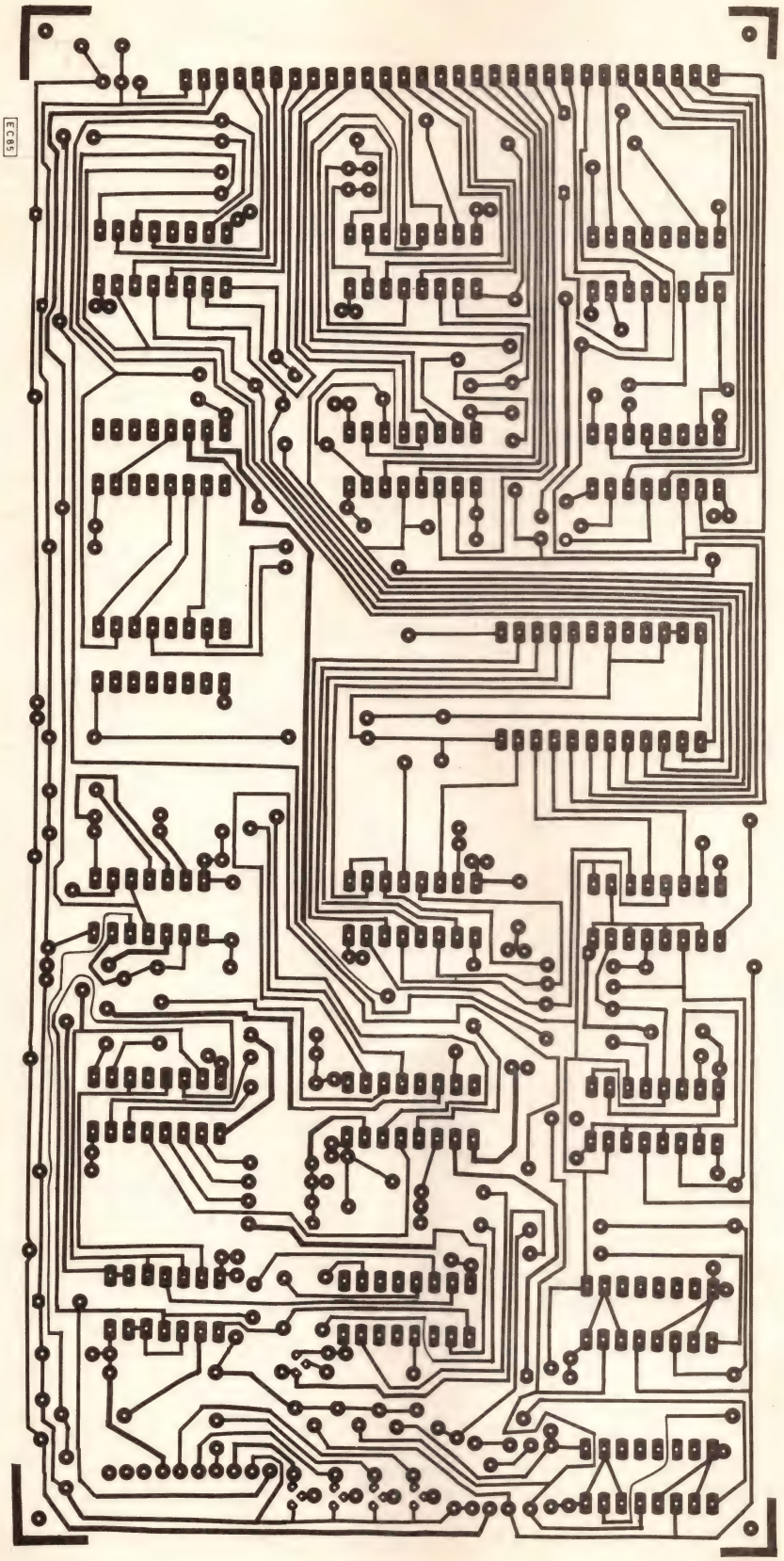


Fig. 2.4. Printed circuit board (actual size)

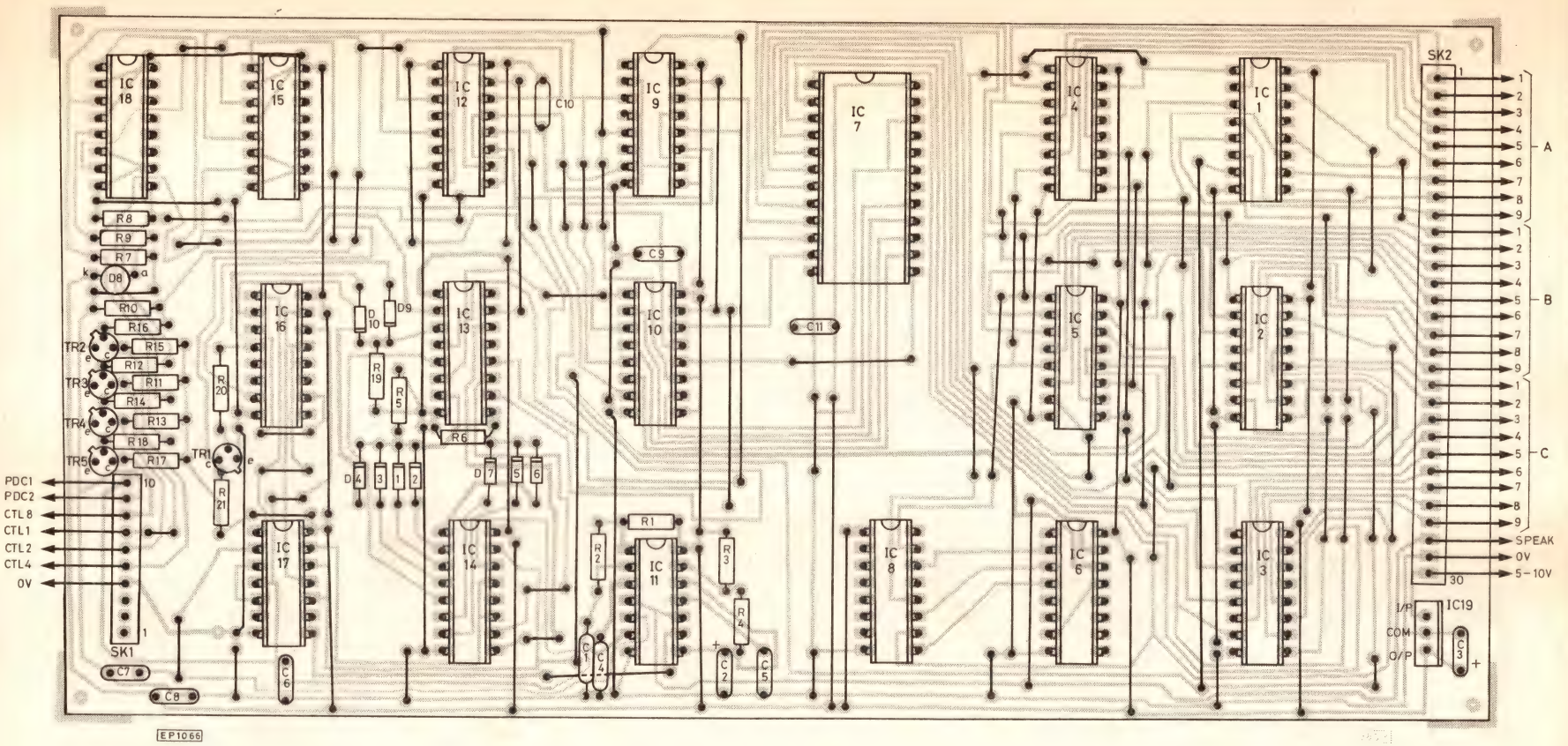


Fig. 2.5. Component layout

FROM READ-OUT TO SPEAK-OUT

a single port to a maximum of 64 words. In addition, three word messages can be formed by linking the EPROM out and switching each input port to give the address data of the respective word. A circuit for the EPROM substitute is shown in Fig. 2.2.

The interface circuit consists of 7 four bit high impedance buffers connected to a 4 bit CTL bus. Each one of the buffers can be latched in turn to the CTL bus by means of two decade dividers which are wired in series. A further 9 bit bus is formed on the input to the board. Data which is present on any one of the three, 9 input ports, can be selected sequentially to form either an address for the code conversion EPROM or, if a jumper strip is inserted in the EPROM socket, the address of the look-up table of the word required. Each one of the 9 bits in all three inputs must be terminated to 0 volts or + 5 volts for the board to operate successfully.

The output from the EPROM is connected to two 4-bit CTL buffers. The remaining four 4-bit buffers on the CTL Bus are wired in such a way that, when they are enabled, they produce the four following instructions:

0000	RESET
0010	LOAD ADDRESS
1100	READ & BRANCH
1010	SPEAK

CIRCUIT DESCRIPTION

When the speak input is brought high, both 555 timers start to run. Timer A runs at a frequency of 10kHz. Timer B can be set to give the rate at which the words are spoken. The first three clock pulses from 555 timer A step the decade counter and enable the 0000 buffer. Hence, three reset instructions are given to the processor. The next clock pulse enables the 0010 buffer which instructs the processor that the following nibble will be an address. The lower nibble from the EPROM is then latched to the CTL bus via its respective buffer. Once it receives a further clock pulse the decade counter is stepped and the 0010 buffer enabled. This is followed in turn by the upper nibble of the EPROM output being loaded onto the CTL bus. The decade counter then enables the 0010 buffer once more followed by the third 2-bit data buffer. The 0010 buffer is again enabled and followed on the next clock pulse by loading the 0000 buffer as data.

The decade counter then enables the 1100 buffer thereby instructing the processor to READ & BRANCH. The next clock pulse latches the 1010 and the processor begins to speak the first word. During this time the l.e.d. is switched on.

The decade counter is then held until the second 555 timer B times out. This steps the input counter IC10 which in turn enables the second 9-bit data port. In addition, the decade counter is reset and the above sequence repeated, thereby producing the second word.

The third word is produced when 555 timer B times out for the second time. This again resets the decade counter and steps the input counter which in turn latches the data present on the third input port onto the input bus.

The input counter is stepped once more, thereby causing it to latch, which in turn inhibits 555 timer B and hence the sequence is halted.

CONCLUSIONS

The voice synthesis board can be used in most applications where speech is needed. It has the capacity to speak phrases of between 3 to 64 words; it can cope with coded input such as seven-segment or BCD, and it can be operated by a microcomputer or simply as a stand alone unit for application in the house, car or factory. ★

COMPONENTS . . .

Resistors

R1, R2, R3, R5, R6, R11, R13, R15, R17, R19, R21	10k (11 off)
R7, R8, R9, R10	1k (4 off)
R4, R12, R14, R16, R18	22k (5 off)

Capacitors

C1, C7	10n (2 off)
C2	10µ
C3	4µ7 elect
C4, C5, C6, C8, C9 C10, C11	100n (7 off)

Integrated Circuits

IC1-IC5, IC9, IC10, IC12, IC15, IC18	74LS367 (10 off)
IC11	556
IC6, IC14, IC16	4017 (3 off)
IC7	2716
IC17	4001
IC8, IC13	4049 (2 off)
IC19	78M05 Regulator

Transistors

TR1-TR5	BC108 (5 off)

Diodes

D1–D7	1N4148 (7 off)
D8	L.e.d.

Constructor's note

Full kits of parts are available from the **Warwick Design Group,** 12 St. Georges Rd., Leamington Spa. (0926 34311) at £24 each. Kits to build the Voice Synthesis Boards are offered at £37.

BAZAAR

MICROTAN 65 Factory built. £45. S. R. Powell. Tel: (07818) 7238. 3 Churnet Road, Forsbrook, Stoke-on-Trent, Staffordshire ST11 9BP.

BOUND volume R.C. '71–'72, plus 100's of P.W., E.E., R.C. offers. Mr. F. Edwards, 46 Longstaff Road, Southfields, London SW18.

2 METRES for £25. Multichannel Storno Viscount, working perfectly with toneburst and handbook. Buyer collects. Tel: Biggleswade 315075. Mr. M. J. Strange, 19 Wilsheres Road, Biggleswade, Beds.

100 UNUSED boxed valves, £50. Also 3,000 circuits, £50. R. MacDonald. Tel: Folkestone 75541.

8080 Components. CPU's, DMA's, USART's etc. Only a few of each. Send s.a.e. for details. Robert Malos, 204 Corporation Rd., Grangetown, Cardiff CF1 7AY.

WANTED for 19 Set MKIII I ATU, vibrator p.s.u., full circuit data. Copies o.k. Also any HRO circuit data. A. C. Baglin, 19 Fore Street, North Tawton, Devon EX20 2DT. Tel: North Tawton (083782) 354.

COMPUTER grade p.s.u.'s. Advance 5V 20A. Advance 5V 40A. New. Sensible offers, please. Service manual, Tektronix 475 'scope. J. Dykes, 2 Aire Place, Winsford, Cheshire. Tel: Winsford 51303.

SANWA ST4-3BF radio control four channel, three servo, unwanted present. £75 o.n.o. Tel: Horndean 593502. L. J. Mundin, 111 Hazleton Way, Horndean, Hants PO8 9DN.

WOLSELEY 4/44 1954 l.h.d. Collector's item, no rust. Swop quality, little used, video recorder and tapes. M. Pennell, 13 Kilmiston Ave., Shepperton, Middx. Tel: Walton on Thames 25763.

MAJOR 588 80ch AM/FM/SSB, £70. Pair AX10M 10 speakers, 10 watt, 10 inch, £10. Tel: Gainsboro (0427) 5848. D. Trebble, 2 Pendeen Close, Gainsboro, Lincs DN21 1YE.

UNUSED TMK 500TU-B Multimeter with case and leads. £20. Tel: Yateley 870628. Mr. F. Lucas, 6 West Fryerne, Yateley, Nr Camberley, Surrey GU17 7SU.

NEW SERIES

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A. (Hons)

IN the early days of semiconductor design the variety of components available for general use were fairly limited. Transistors, diodes, and passive devices were predominantly used, and most circuits contained various combinations of these devices. The design emphasis was very much based on the methods and arrangements of interconnecting these devices, and on the passive component values used. Nowadays, the integrated circuit is the dominant type of component, with many circuit designs having no discrete transistors in them at all. Unlike diodes and transistors, however, the performance and operational parameters of an i.c. are often very difficult to specify. The electrical limits of performance must be detailed, of course, but the precise functioning and operation of the device must also be explained. For many i.c.s this explanation requires a number of tables, timing diagrams, and waveform diagrams. As a result, data sheets become very complex and contain a large amount of information which must be thoroughly assimilated before design can begin.

Many readers would like to use new semiconductor devices in their own projects but are daunted by the research necessary to enable them to do so. Initially, a suitable device has to be found, and then the relevant data has to be obtained; if it can't be found in a supplier's catalogue, then from whom? Many people don't have access to professional data services or distributors' information. Even if data has been satisfactorily obtained, it's often written in such a way that it proves difficult to put into practice. This is where we come to your help! This series of "application reports" features different semiconductor devices (mostly integrated circuits) with their pin connections and essential data clearly given. In many cases all the data that's available won't be given since much of it is of little value in the majority of design work and it would take up many pages every month! All the essential data will be given which as a result will be much easier to read and understand. Included will be a comprehensive description of how the device works, how it can be used, hints and suggestions for circuit arrangements, circuit diagrams, and finally a Veroboard layout for a typical circuit. This will give all the information needed to enable you to use the i.c. with confidence in designs of your own, often as a base for a larger project.

RANGE COVERED

The semiconductor devices looked at will cover the whole range of electronics with the exception of very specialised devices such as microprocessors (covered recently by "Microfile"), r.f., microwave, etc. These will range over op amps, audio amps, consumer i.c.s, display devices, encoders, decoders, power supply i.c.s; all these and many more will be covered. Some devices will be very new indeed, giving you access to the very latest technology. Others will be recently introduced or more familiar devices; the aim is to provide a comprehensive and wide ranging service.

Each month just one device or a small family of similar devices will be presented. However, to get the series off to a flying start, we feature two chips this month: an electronic combination lock, the **LS 7225,** and the **SAB 0600** door chime.

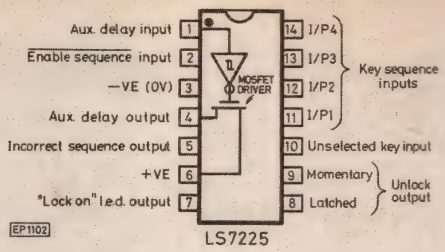
COMBINATION LOCK (LS 7225)

The LS 7225 is a relatively new and very interesting 14 pin i.c. which takes a lot of the effort out of designing an electronic combination lock. It's a monolithic PMOS device, rated at up to 18 volts supply, and has a low quiescent supply current which allows it to run for a very long time on a small battery if required.

It has sequential logic to detect a valid sequence of four key depressions. There are three main outputs of the i.c.; one directly drives a l.e.d. to indicate when the device is in the locked state, a second latches to the on condition (logic 1) when the correct code has been entered, and the third provides a momentary on signal (again a logic 1) when the correct code has been entered. If any "unused" keys are pressed, or if any of the correct keys are pressed out of sequence, an "Incorrect sequence output" of the i.c. is pulsed to logic 1 (i.e. a high level), and no changes occur to the main outputs of the device.

Various enable and delay facilities are also provided to ensure that a delay of several seconds or more is necessary between entering one code and being allowed to enter another one. This helps to prevent a light fingered person from typing in all possible combinations in a very short time! All the inputs have built in pull down resistors to help minimise the external component count. Power on reset is provided to set the i.c. into the "locked" state when power is first applied. Following such an application of power, the first correct sequence entered turns the lock off, then the next correct sequence turns it on again. The two main "unlock" outputs can drive many relays directly, providing that coil resistances of 1k or more are used.

Fig. 1. LS7225 pin out with the aux delay circuitry shown internally. The specification is shown below



Characteristic	Notes	Min	Typical	Max	Units
Supply voltage	No input should exceed supply voltage	4		18	V
Quiescent current (I/P's & O/P's open circuit)	Supply = 5V			20	µA
	Supply = 12V			40	µA
Temperature range		−25		70	°C
"Lock on" l.e.d. output current	Supply = 5V	0·6	1·0	1·3	mA

Characteristic	Notes		Min	Typical	Max	Units
(Voltage limited to +1·7V)	Supply = 12V		6·5	8·7	11·0	mA
Unlock outputs (Logic 1)	Supply = 5V, O/P = 3V		2·2	3·0	4·1	mA
	Supply = 12V, O/P = 10V		9·0	11·6	14·4	mA
Incorrect sequence output (Logic 1)	Supply = 5V, O/P = 3V		0·5	0·7	0·9	mA
	Supply = 12V, O/P = 10V		2·0	2·6	3·2	mA
Aux. delay output	Supply = 5V, O/P = 3V		0·4	0·6	0·8	mA
	Supply = 12V, O/P = 10V		1·8	2·4	3·0	mA
Load current, all inputs	Supply = 12V, I/P = 0V			6		µA
Key sequence Input 1	Logic 0	Supply = 5V	0		2·0	V
	Logic 1		3·5		5·0	V
All other inputs	Logic 0		0		2·0	V
	Logic 1		4·0		5·0	V

KEY SEQUENCE INPUTS

These inputs are taken to logic 1 (i.e. a high level) by the relevant switches of the switch bank or keypad. Input 1 should be held at logic 1, while 2 is taken to logic 1 momentarily, followed by 3, then by 4. Only after Input 4 has been operated should Input 1 be allowed to go open circuit (or to logic 0); see the timing diagrams, Figs. 4 and 5, for clarification of this. Alternatively, by taking a capacitor from Input 1 to ground, the logic 1 level will be maintained for a short period after the first switch is released, giving a "time window" in which the other switches may be pressed. A 1µ tantalum capacitor will typically give a 4 second delay, which is quite long enough to allow the pressing of the other three switches. Note that this will also result in a delay before any further sequences can be entered; once the capacitor has been charged, it must be allowed to discharge before another sequence is started.

UNSELECTED KEY INPUT

All the unused switches or keys are connected in parallel and taken to this pin. Hence, if any incorrect key is pressed, this pin is taken to logic 1, the sequential logic is reset, and a pulse is fed to the "Incorrect sequence output" pin.

UNLOCK OUTPUTS

The momentary unlock output goes to logic 1 as soon as the correct sequence of switch or key inputs has occurred. It returns to logic 0 as soon as "Key sequence" Input 1 returns to logic 0, either when the first key in the sequence is released, or (if one is fitted) when the capacitor discharges a few seconds later. The latched "Unlock output" also goes to logic 1 as soon as the correct sequence of key inputs has occurred. To reset this to logic 0 (the "system locked" condition), the whole correct sequence must be entered again.

"LOCK ON" OUTPUT

This directly drives an l.e.d. with no need for any external resistor. This is lit when the lock is on, i.e. when the latched "Unlock output" is at logic 0.

Pin 3 is normally at 0V. Pin 6 is the +ve supply, which can be anything from +4V to +18V. As a rule of thumb, try not to go above +15V generally, to guard against any supply voltage fluctuations or noise pushing the voltage above the maximum rating for the i.c. Some capacitors across the supply rails should also be provided for decoupling; in Fig. 2 these are C5 and C6, with R1 and C1 providing further supply decoupling.

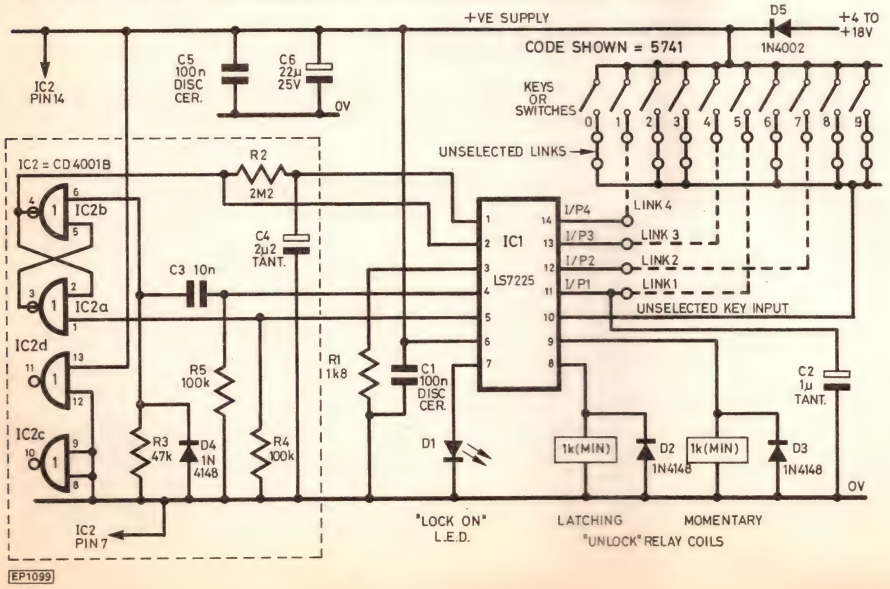
INCORRECT SEQUENCE OUTPUT

This gives a positive going pulse out (to logic 1) when any form of incorrect code sequence is entered. This pulse is extremely short in duration, only 15µs approximately, so be careful how you use it.

ENABLE SEQUENCE INPUT

This input, in common with all the others of the i.c., has a pull down resistor fitted internally, and is normally kept at logic 0 (or open circuit) to allow the system to operate. If it is taken to logic 1, then the sequence detection circuitry is disabled. This can be used in conjunction with the "Aux. delay" facility and the "Incorrect sequence output", to provide a fixed delay (following an incorrect sequence entry) before another attempt at entering the correct sequence is allowed.

Fig. 2. Combination lock circuit. The dotted box gives optional 12s delay between successive codes. If not required connect IC1/2 to 0V. The links should be connected for the required key sequence with the unselected links in parallel



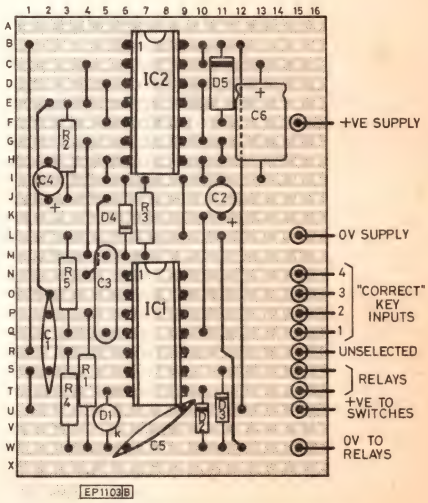


Fig. 3. Veroboard assembly

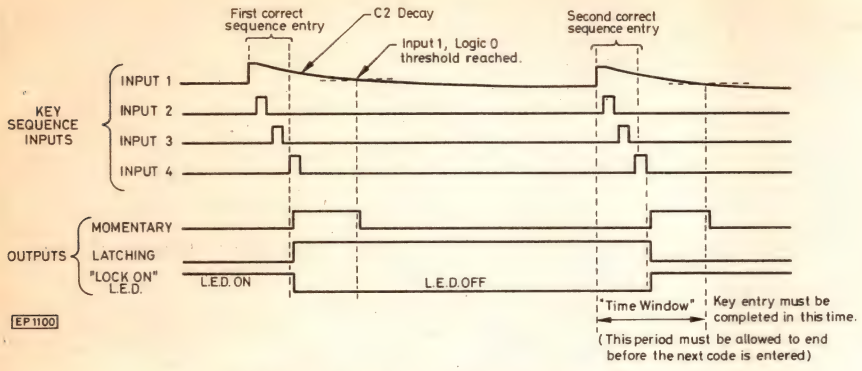


Fig. 4. Timing diagram, correct sequence

AUX DELAY INPUT/OUTPUT

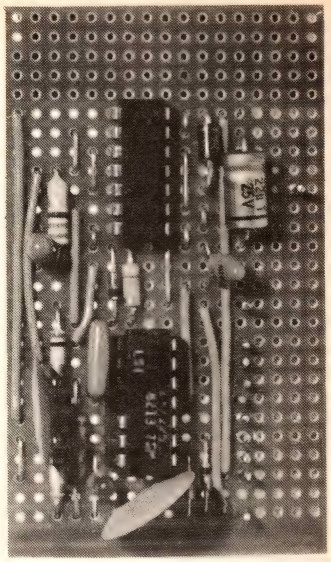
The internal circuitry for this is shown in Fig. 1. When pin 1 is taken high (towards logic 1), the Schmitt trigger inverter's output goes to logic 0, turning on the MOSFET output stage and feeding a logic 1 level to pin 4. An RC timing network can be used to delay any signal fed to pin 1, which is "cleaned up" into a sharp edged logic change by the Schmitt trigger input of the inverter, and fed to pin 4 as just described. See Figs. 2 and 5 for further clarification of how this works in practice.

POINTS TO NOTE

Because of the internal pull down resistors, no external ones are needed except for the "Aux. delay input". However, beware of taking any input up to the positive supply with a resistor, since the internal and external resistors will combine to form a voltage divider, making the input voltage to the i.c. poorly defined. If you must use a pull up resistor, try to keep it down to just 1 or 2 kilohms if possible. The outputs at pins 4, 5, 7, 8 and 9 are all unloaded MOSFET driver stages; when "on" their output voltage is nearly at the positive supply rail, but when "off" their outputs do not go to 0V of their own accord; they merely become open circuit. If these outputs are being used to drive into any other logic circuitry, add a suitable load resistor to 0V; the 100k resistor R4 in Fig. 2 is being used for just this purpose.

The Veroboard layout for the circuit is shown in Fig. 3. As usual, take care with the handling of both i.c.s, and avoid touching the pins with your fingers. D5 protects the circuit against the supply being connected the wrong way round; since this may be a battery, it is a worthwhile precaution. Don't forget to add D2 and D3 to protect the i.c. against back-e.m.f. spikes from any relays that you might connect to the circuit. The more switches that are provided, then the more difficult it is to crack the code; you could consider having, say, 26 cheap switches on a panel, with the correct four switches spelling out an appropriate word! For high security applications, the "Incorrect sequence output" could be used to trigger an alarm circuit, so that the user would only ever get one attempt at entering the correct code. Alternatively, consider cascading two i.c.s in series, so that you have to enter eight keys in sequence to operate the circuit. Use the first i.c., when sequenced correctly, to enable the second one.

Finally, remember that it isn't restricted to only working with switches as inputs; the i.c. would make an excellent detector for logic sequences too. A set of four consecutive logic pulses, in the correct order only, would trigger the device.



Altogether, it's a very versatile and interesting device!

A similar i.c. to the LS 7225 is also available: The LS 7220 does not have any "Incorrect sequence" facility, but can instead be made to temporarily over-ride the sequence decoding logic, so that anyone can operate the lock, even if they do not know the correct sequence. (Naturally, the i.c. can then be switched back to operate in the "normal" mode.)

Both i.c.s can be obtained from **TK Electronics.**

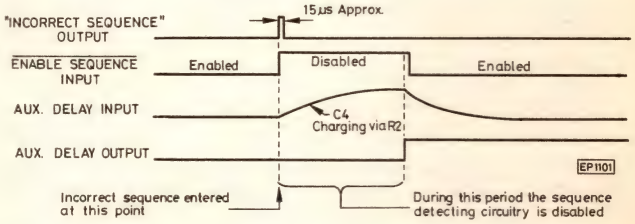


Fig. 5. Timing diagram, incorrect sequence

THREE TONE CHIME (SAB 0600)

The all-electronic doorbell has been a popular concept for many years now, being originally based on simple analogue techniques, then later involving digital control, culminating in today's microprocessor based designs. Just about every tune that you could think of can be played whenever the milkman calls. The only thing that the majority of these doorbells seem unable to play is a good, simple, traditional, "ding-dong"!

The SAB 0600 is an 8 pin i.c. from Siemens which is designed specifically to provide such a chime. In fact, it's more a case of "ding-dang-dong", since three tones of descending order of frequency are provided, not just two. The tones are harmonically related so that the chime is always in tune, and sophisticated logic control provides for a realistic and pleasing decay of sound level. There is even a power amplifier provided in the device, so that only half-a-dozen passive components plus a switch and loudspeaker need to be added to make a complete door chime.

The block diagram of the i.c. is shown in Fig. 7. When the device is triggered (by taking pin 1 to the positive supply) an internal regulator is turned on to supply regulated power to the rest of the internal circuitry. A high frequency master clock oscillator is provided, with its frequency determined by an external RC network connected to pins 6 and 7; varying either the R or the C will cause a change in the oscillator frequency. The output of the clock oscillator feeds into a digital tone generation circuit. The master clock is divided down to provide the three chime frequencies, ensuring that the musical relationship between the tones is kept constant, and hence the chime will remain in tune. The master clock is then divided down still further, and this very low frequency square wave is used to control the timing of changes in relative amplitude of the three tones. The amplitudes are controlled independently, so that the first tone is decaying away when the second one starts, and both the first and second tones are decaying away when the third one starts. The result is a very natural and melodic sequence; in fact, if you listen very carefully to the chime you can actually hear the amplitude decreasing step by step at the end of the sequence as the final decay progresses.

The three separate outputs of the digital tone generator are mixed together at the summing input of the power amplifier. The latter is designed to drive a load of 8 ohms or more, which must be capacitively coupled via a 100µ

capacitor. Under these circumstances the i.c. will deliver 100mW without the need for any heatsinking.

Finally, an external capacitor between pin 8 and ground (0 volts) will act as a filter, rolling off some of the high frequency content of the square waves. The more filtering that is applied, then the subjectively quieter the chime seems to be, although of "smoother" tone, so the adjustment of this is a matter of personal preference. The chip's internal power supply shuts down when the tones have ceased. This reduces the current consumption to less than 1μA, which in combination with the supply voltage requirements of 6 to 11 volts makes the device ideal for powering by a small 9 volt battery.

BASIC CIRCUIT

The basic chime circuit is shown in Fig. 8. Varying R2 or C4 adjusts the frequency of the chime tones, and (because the timing of the digital tone generator is also derived from the master clock) the duration of the chime sequence; the higher the tones in frequency, then the shorter the sequence will last. The value of C5 can be adjusted to give the most suitable tone to the chime.

If the chime is too loud for your liking, add a resistor in series with C2; anything up to 20 ohms should do the trick. C1 and C6 must be in place and as close to the i.c. as possible, since they ensure the stability of the whole circuit. Normally the three tones come in the order of descending frequency. If instability is present, the tones may seem to increase in frequency, or even change frequency as they are decaying away. The cure for this is simply to add more capacitance; increase the value of C1, or add more 100n disc ceramic capacitors across the supply rails close to the i.c. If the switch is very far away from the i.c. then add an 82k resistor between it and pin 1 of the i.c. (close to the chip itself) to limit any spurious induced currents to an acceptable level.

ELABORATING IT

The basic circuit of Fig. 8 works very well, but for the adventurous there is a more sophisticated circuit shown in Fig. 9, with its Veroboard layout given in Fig. 11. Two switches are provided, "Doorbell 1" and "Doorbell 2", so that both front and back doors of your house can be connected to the circuit. Doorbell 1 will give a short duration high frequency chime, and Doorbell 2 a longer, low frequency chime.

IC2c and IC2d form a simple flip-flop or latch circuit. If the Doorbell 1 switch is pressed, IC2d pin 11 goes to logic 0 and IC2c pin 10 goes to logic 1. This situation remains constant (even after the switch has been released) until Doorbell 2 is pressed, when IC2d pin 11 goes to logic 1 and IC2c pin 10 goes to logic 0, etc. IC3 is a quad CMOS analogue switch. This acts in a similar way to a relay, but in solid state form; if pin 13 (a "control" pin) is taken to logic 1, then pins 1 and 2 become "connected together" via a 300 ohm resistor internal to the i.c., and can pass analogue signals bidirectionally. Hence, if pin 13 goes to logic 1 and pin 12 is at logic 0, R3 is effectively connected between pins 6 and 7 of IC1, with R2 remaining unconnected. Similarly, if pin 12 is taken to logic 1 with pin 13 at logic 0, R2 is connected between IC1 pins 6 and 7, and R3 remains unconnected. By this means, the two doorbell switches will connect different resistors to IC1, which in turn will cause different frequencies of chime to be heard. IC2a and IC2b are merely connected to make an OR gate; if either one switch OR the other is pressed, then the chime i.c. is triggered.

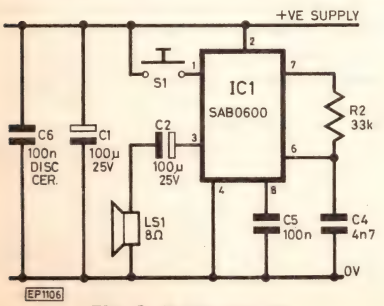
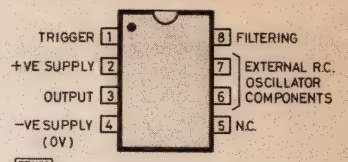


Fig. 8. Basic circuit

Fig. 6. SAB 0600 pin out with specifications set out below



Characteristic	Notes	Min	Typical	Max	Units
Supply voltage		+7	+9	+11	V
Quiescent current	I.c. in idling condition (Not chiming)			1·0	μA
Temperature range		0		70	°C
Power dissipation	Driving 8 ohm load		100		mW
Max output voltage	Driving 8 ohm load	2·1	2·5	2·9	Vpk/pk
Min trigger voltage needed at pin 1		0·5		1·5	V
Input resistance at pin 1		5	7·5	10	Kilohms
Max current into pin 1		−2		+2	mA
Load impedance (at output)			8		Ohms

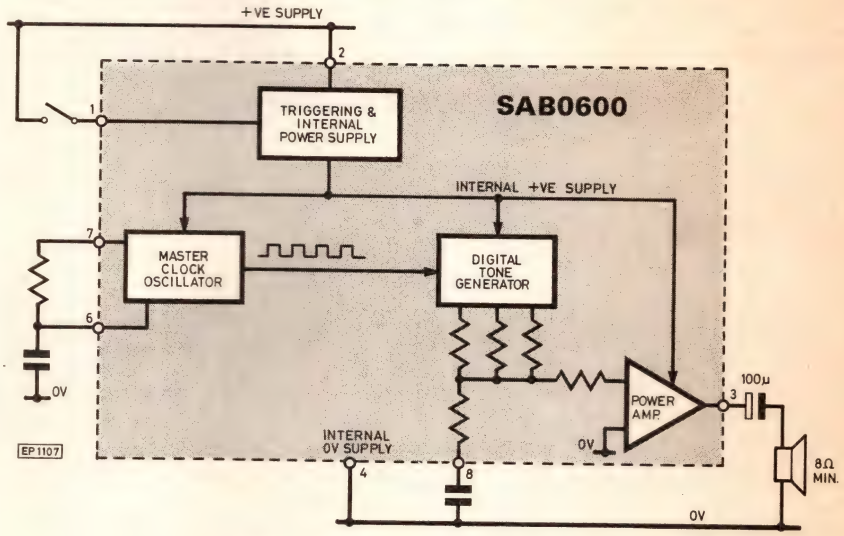


Fig. 7. Block diagram of SAB 0600

CIRCUIT NOTES

R1 and C3 provide some simple filtering to help prevent the triggering of IC1 by spurious pulses. R6 and R7, together with D1, D2, D3 and D4, protect the circuitry against short duration high voltage pulses induced into the lengthy wiring between the doorbell switches and the actual circuitry itself. R4 and R5 provide biasing for the flip-flop when the switches are released. Changing the value of R3 will vary the low frequency chime, and changing R2 will similarly affect the high frequency chime. As with the simple circuit of Fig. 8, don't forget that R10 can be added to reduce the loudspeaker volume if required. Make R10 a wire link for full volume. C5 can be varied to alter the tonal quality of the chime. Again, be careful with decoupling capacitors C1, C6 and C7; add to these if instability is a problem. Finally, note that D5 is used to protect the circuit against incorrect connection of the battery — always a good

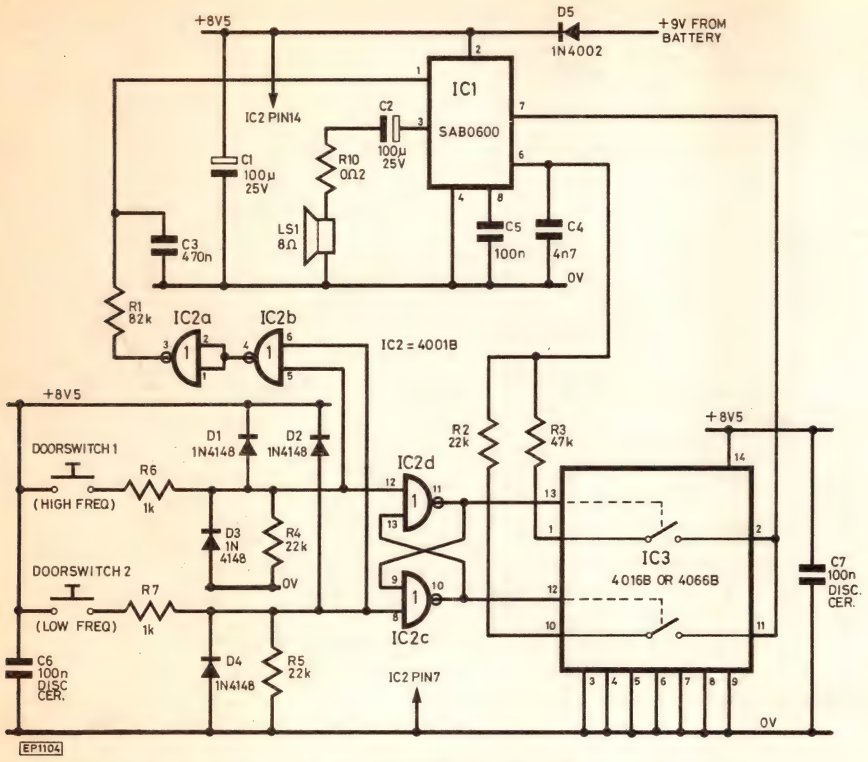
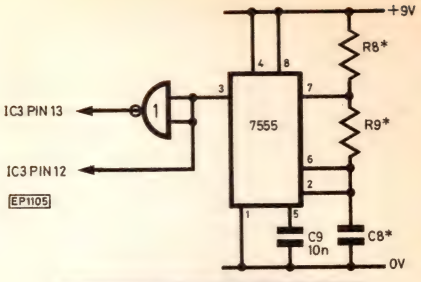
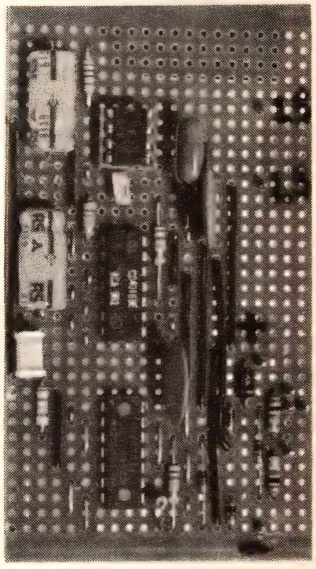


Fig. 9. Sophisticated chime circuit





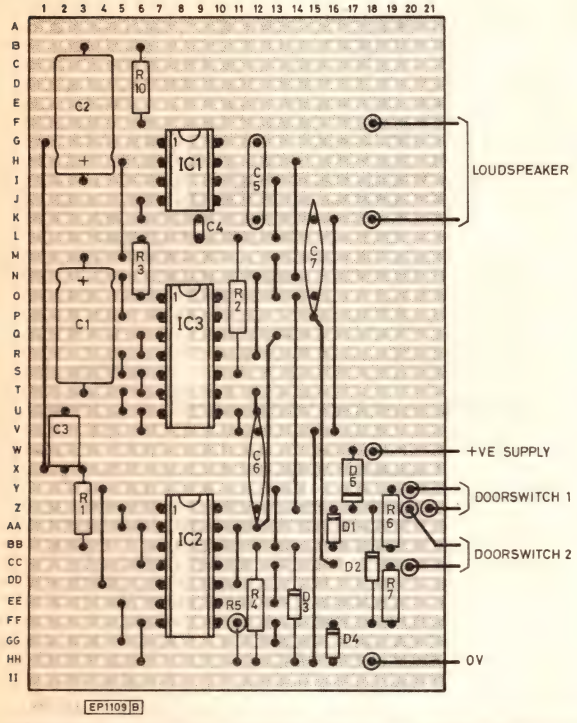


Fig. 10. (Top right) circuit for varying pitch during chime. The gate is ¼ of a 4001B and R8, R9 and C8 are 33k, 470k and 100n to 2µ2 respectively

Fig. 11. (Left) Veroboard assembly of three tone chime circuit

idea! Battery life will be many months in normal use, because the SAB 0600 turns itself off when not in use, and the CMOS i.c.s draw negligible current.

If more loudspeaker power is needed than can be provided by the i.c.'s own amplifier, then replace C2 by a 100n capacitor, and the loudspeaker by a 100k resistor (almost any values will do here), then feed the connection between this capacitor and resistor out to an external power amplifier. The signal level may need attenuating, though!

Why not experiment more with the circuit; running two SAB 0600 i.c.s together simultaneously could prove interesting, giving the effect of musical chords being played. Alternatively, try connecting the circuit of Fig. 10 to IC3 pins 12 and 13 in place of the circuitry shown in Fig. 9; this will cause a continual changing of frequency actually during the chime, which is a very strange sound indeed. Perhaps in the end, though, the most pleasant effect is the original one: a simple, melodious, three tone chime, which is a welcome change from so many modern electronic doorbells!

The SAB 0600 is available from **TK Electronics,** who also sell complete doorchime kits based on this i.c.

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SONY CV2000 Video. 405 lines, reel to reel, recorder, camera, monitor/T.V., microphone, tripod, cables, tapes, carry-case. £180 o.n.o. R. Swale, Oak Cottage, 616 Reading Road, Winnersh, Wokingham, Berks. Tel: Wokingham 784035.

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JUNE ISSUE ON SALE FRIDAY, MAY 6, 1983

Space Watch...

THE IRAS SATELLITE

After three years of working and planning the International Infrared Astronomical Satellite (IRAS) was launched successfully in January. The allocation of responsibility for this international project was distributed between the United States, the Netherlands and the United Kingdom. The act of launching was celebrated by an all night watch of the pre-launch procedures at the Rutherford Appleton laboratory, to which not only active participants in the project were invited but also their families, the press and other visitors. The personnel on duty were fully occupied with their particular tasks and routines, but all this activity was made available to the guests by the monitor screens set up in the lecture theatre. Continuous monitoring was available and all the countdown procedures could be observed.

Between events the visitors were given tabloid information from various members of the staff. Since each stage of the proceedings from the launch site at the Vandenberg Air Force Base in California was via live voice relay, the frequent "Mission completed" indicated in a loud voice as each procedure was finished often broke in over the local speakers voices. This seemed to increase the level appreciation to those assembled. It was clearly a stroke of admirable planning to bring together those most concerned while problems were being solved, often involving long hours of waiting for the families at home. The very intense excitement of the last period, before the actual final count, was filled with thoughts of other launches, yet each time the anticipation is still felt as though it was the first time.

Visitors from America, the Netherlands and other countries together with the press were restless during the final seconds and none could resist audibly counting with the rest. At the moment of lift-off the tension was released and everyone turned to his and her neighbour applauding. The excitement continued through the stages to the time of the satellite being inserted into the correct orbit and the signals returned to say that the Satellite was fully operational. Finally for those more technically concerned a quick rush to the refreshments and into groups to discuss the programme and to get ready for the first pass of the satellite over the control station at the SERC Laboratory at Chilton.

The official programme began at 1.00a.m. on the 26th January with a welcome to the Rutherford Appleton Laboratory at Chilton by Dr. G. Manning the director of the laboratory followed by a brief introduction to the purpose of the project by the United Kingdom project manager Dr. Eric Dunford. This was followed by a talk from Professor Richard Jennings of University College, London on the place of the infrared telescope in astronomy. He was interrupted by the announcement from the launch site that it was "GO". At 1.30a.m. The technical schedule of events was given by Eric Dunford. The science analysis manager Dr. G. Thomas, then took over with a description of the operations involved at the control centre. Mr. Peter Doms of the Telescope Support Team gave information of the early operations and an explanation of the monitor screens placed in the lecture theatre so each step of the operations could be observed at all the centres. This part of the "show" was constantly interrupted as the launch preparations continued.

Then followed the launch itself. At 2.21a.m. the command signal was sent from Chilton to the Goldston tracking station, at 2.25a.m. the LOS (loss of signal) indicated that the pass over the Goldston sector had been successful and that the satellite was on its way over the Indian Ocean. At 3.11a.m. the AOS (acquisition of signal) and at 3.24 the LOS, followed by the Chilton pass at 3.29a.m. Throughout the Chilton acquisition of signal the movement of the controlled dish at Chilton, fully floodlit, was observed. In its turn the LOS for Chilton was signalled and at 3.44 first results of the passes were recorded. There was a final pass over Chilton at 5.19a.m. which was watched by the enthusiasts and the Press from the windows of the control room.

INFRARED ASTRONOMY

Recently a new dimension was brought into being using the UKIRT (United Kingdom Infrared Radio Telescope) high up on the mountain at Haiwai. This new dimension was the operation of the control centre at Edinburgh Observatory where sitting at a console the astronomer could operate the telescope and carry out normal duties. This was reported in detail in a recent issue of *Spacewatch*. It might therefore be thought that this new telescope operating in space is duplicating facilities. There is a very important reason for the new telescope which will in the course of the next 6 to 9 months complete the most comprehensive view of the infrared spectrum of the Universe. This reason lies in the fact that though a great deal of data has been collected there are gaps in the actual spectrum which cannot be "seen" from Earth. The reasons for this situation are concerned with the "forbidden" wavelengths which cannot be seen through the Earth's atmosphere for a number of reasons. It becomes necessary then to go outside the Earth where the whole spectrum can be observed.

There is another very important matter to be considered. This arises from the fact that the level of the radiation may be very low. To take this into account the sensitivity of the new telescope is such that it can detect levels down to one million, trillionth of a watt per square centimetre. Special design and cryogenic operation becomes necessary to accomplish this. Yet though the signal at the receiver may only be minute the actual source and origin may be extremely great and energetic. This is the tremendous importance of the satellite telescope.

The heart of the satellite is the telescope. It is an f/9.6 Ritchey-Chretien type design with a 22·4 inch effective aperture of primary mirror. The mirror itself is of light weight Berryllium. The effective field of view is 30 arc minutes. It has a focal length of 5,500mm. There are 62 rectanglular detectors which vary in size from 7·2 × 1·2mm to 7·5 × 5mm. These detectors form the focal plane array at the base of the telescope. The detectors observe in four wavebands

Band 1. 8·5–15 microns
Detectors 15 silicon–arsenide.
Band 2. 19–30 microns
Detectors 16 silicon–antimonide.
Band 3. 40–80 microns
Detectors 16 germanium–gallium.
Band 4. 83–119 microns
Detectors 15 germanium–gallium.

The detectors are so arranged that each source encounters two detectors in each of the four wave bands which produce a 'signature' for a point source. By this method each area of observation is covered four times giving a possible source detection coverage of eight. Some of the special observations will involve the examination of well known asteroids and new ones that may be encountered. Thus this satellite will deal with almost any type or source of infrared that may be scanned by the telescope.

THE DUTCH EXPERIMENTS

There is an additional Dutch experiment called DAX which consists of three instruments. These are also located near the focal plane. One instrument is a low resolution spectrometer which will produce sectra between the wavelengths of 7·4 and 23 microns. This will aid in the identification of sources of infrared. A second instrument will operate between 4·1 and 8 microns. The third instrument is a "chopped" photometric channel and has two detectors in two bands between 41 to 62 microns and between 84 and 114 microns. The shutters are operated so that every fifteen seconds a shutter opens and each closes in such a way that all energy is shut out. During the period of closure the instrument is automatically calibrated.

ATTITUDE CONTROL

The attitude control of the IRAS is a digital subsystem with an accuracy of 30 arc seconds (1/20th of a degree). It is expected that the operation techniques will lead to a pointing ability of a few arc seconds over small areas but in any case the data accuracy of pointing will be better than 20 arc seconds. There are sun sensors around the satellite to ensure Sun acquisition during the initial operating period. It is important to keep the telescope aperture away from the Sun, the Moon, and the Earth. Part of this is assured by the use of a special cold mirror coated screen which reflects unwanted infrared away from the aperture of the telescope.

A primary computer and an identical backup is provided on board. Transfer of data from the satellite is stored on a recorder and, for the ordering of the daily programme each section of work programmed has various special memory facilities.

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75173		1.44
75174		1.95
75175		1.44
75182		0.50
75183		0.50
75188		0.37
75189		0.37
75451		0.22
75452		0.22
75453		0.22
75454		0.22
75468		0.88
75491		0.31
75492		0.42
AY31015	*D2*	3.00
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TL084	1.58
TL091	0.40
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1.8432M	1.92
2.4576M	2.00
3.6864M	1.86
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6M	0.86
8M	0.86
9.8304	1.68
19.6608	2.48

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14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
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4000	0.10
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4002	0.12
4006	0.42
4007	0.14
4008	0.32
4009	0.24
4010	0.24
4011	0.10
4012	0.16
4013	0.20
4014	0.40
4015	0.36
4016	0.20
4017	0.32
4018	0.36
4019	0.36
4020	0.36
4021	0.40
4022	0.40
4023	0.13
4024	0.32
4025	0.13
4026	0.74
4027	0.20
4028	0.32
4031	0.94
4033	1.80
4034	0.94
4035	0.38
4040	0.36
4041	0.36
4042	0.34
4043	0.36
4044	0.36
4045	1.35
4046	0.42
4047	0.70
4048	0.38
4049	0.23
4050	0.23
4051	0.38
4052	0.44
4053	0.44
4054	0.85
4055	0.85
4060	0.39
4063	0.85
4066	0.24
4068	0.14
4069	0.14
4070	0.13
4071	0.13
4072	0.13
4073	0.14
4075	0.13
4076	0.43
4077	0.13
4078	0.15
4081	0.13
4082	0.13
4085	0.50
4086	0.44
4093	0.20
4502	0.46
4507	0.32
4508	0.96
4510	0.40
4511	0.41
4512	0.40
4514	0.96
4515	0.96
4516	0.40
4518	0.40
4519	0.27
4520	0.40
4521	0.90
4522	0.52
4526	0.52
4527	0.52
4528	0.41
4532	0.72
4541	0.50
4543	0.50
4553	1.57
4555	0.35
4556	0.35
4585	0.75

74LS SERIES

00	0.11
01	0.11
02	0.11
03	0.12
04	0.12
05	0.12
08	0.12
09	0.12
10	0.12
11	0.12
12	0.12
13	0.12
14	0.25
15	0.12
20	0.12
21	0.12
22	0.12
26	0.12
27	0.12
28	0.12
30	0.12
32	0.12
33	0.12
37	0.12
40	0.12
42	0.28
47	0.35
48	0.45
49	0.12
51	0.12
54	0.12
55	0.12
73	0.18
74	0.16
75	0.18
76A	0.17
78A	0.18
83A	0.36
85	0.42
86	0.16
90	0.22
91	0.60
92	0.32
93	0.22
95B	0.40
109A	0.27
112A	0.20
113A	0.20
114A	0.22
122	0.28
123	0.34
125A	0.24
126A	0.25
132	0.34
136	0.25
138	0.25
139	0.27
145	0.57
148	0.70
151	0.40
153	0.40
155	0.30
156	0.35
157	0.25
158	0.30
160A	0.32
161A	0.35
162A	0.35
163A	0.35
164	0.40
165A	0.50
166A	0.60
173A	0.55
174	0.40
175	0.36
181	0.90
190	0.35
191	0.35
192	0.35
193	0.35
194A	0.35
195A	0.35
196	0.45
197	0.45
221	0.46
240	0.55
241	0.55
242	0.55
243	0.55
244	0.55
245	0.70
248	0.55
249	0.55
251	0.30
253	0.35
257A	0.30
258A	0.35
259	0.55
261	1.00
266	0.20
273	0.54
279	0.30
283	0.40
290	0.39
293	0.39
365	0.27
366	0.27
367	0.27
368	0.27
373	0.62
374	0.62
375	0.35
377	0.60
378	0.60
379	0.90
386	0.35
390	0.45
393	0.45

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40 PIN	2.32
50 PIN	2.35
60 PIN	3.20

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26 PIN	3.24
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40 PIN	4.90
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60 PIN	6.38

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AUTOMOBILE TEST SET

MICHAEL TOOLEY B.A. & DAVID WHITFIELD M.A. M.Sc.

WORKING on auto electrical systems must rank among the greats in the league table of love-hate activities. The fascination is all but irresistible; the wiring schedule and the components seem so simple and straightforward. In practice, the success or otherwise of any job concerned with auto electrics is based on a sound understanding of the principles involved, and having the appropriate test instruments. The Auto Test Set brings together a range of instruments usually to be found separately, and combines them into a compact and robust unit. By this approach it minimises the number of units which must be brought to bear, and perched precariously under the bonnet or dashboard, thereby minimising many of the frustrations which otherwise lie in wait for the unwary.

GENERAL DESCRIPTION

The Auto Test Set is essentially a group of closely related instruments which have been collected together in such a way that all of the functions remain available, but many of the necessary facilities are shared. An overall block diagram for the test set is shown in Fig. 1, and a summary of the specifications appears in the table. The schematic, and the full circuit diagram shown in Fig. 2, shows that the instruments fall into two main sections; those which use the meter for display, and those which do not.

The first group consists of the voltmeter, the tachometer, and the dwell meter circuits. These all share a common test probe known as the volts/coil probe, and the input signal is simultaneously applied to all three circuits. The output from each circuit can be selected for display on a large moving coil meter, ME1, by means of S1. This switch also effects range switching in the tachometer circuit. A conventional moving coil meter is used because it may easily be read to whatever accuracy required, and with such a display it is very much easier to detect trends; important during tuning and performance testing. A moving coil meter will also have the effect of averaging a signal which exhibits rapid fluctuation which might affect a digital type of display. In order to protect the meter movement from damage when not in use, a carrying position is provided on S1 to short the terminals when not in use. Further protection of the movement is provided by D9 and D10.

The second group of instruments include the circuit tracer and the lamp/fuse tester. Each of these has separate inputs with respect to ground, the V-input and the Z-input, respectively. The circuit tracer uses a voltage comparator and displays the result on a single l.e.d., with an optional audible warning. The lamp/fuse tester uses an impedance comparator and provides a GO or NOGO indication on two l.e.d.s, again with the option of using the (same) audible warning.

The overall instrument derives its power independently from the vehicle under test via SK3 and SK4; D11 provides visual indication of the presence of the necessary supply. The overall instrument is housed in a rugged diecast box, with the majority of the components mounted on a single-sided printed circuit board. The circuit and uses are described below for each constituent instrument in turn, before proceeding to the constructional details next month.

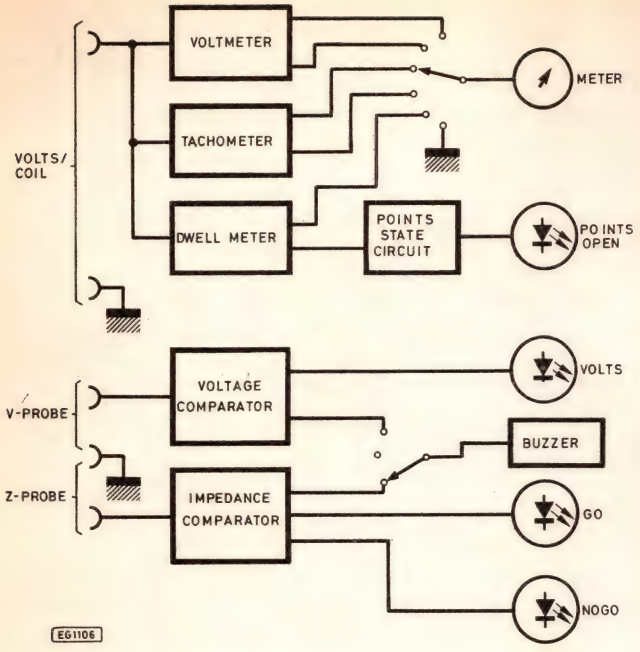


Fig. 1. Block diagram of Auto Test Set

VOLTAGE MEASUREMENT

The Auto Test Set provides two scales for measuring voltages; a simple 0 to 15V range, and a 10 to 15V offset zero range. The first range simply inserts the appropriate series resistance, R12, between the potential to be measured and the meter, ME1. This provides an extremely useful general purpose voltmeter.

In many situations, particularly when interested in the state of the battery, it is rather wasteful to have an instrument which is accurate over a wide range. The range of values to be measured in such situations will usually be at the end of the scale. The provision of an offset zero voltage scale, therefore, allows a much clearer indication of the performance of the battery under load to be obtained. The nominal open-circuit terminal voltage of a conventional six-cell lead/acid battery is 13·2 volts. This value falls under load, especially as the internal resistances of the cells rise due to physical deterioration; and the voltage rises during charging. With the exception of starting, the battery voltage will rarely fall below 11 volts, and the voltage regulator should ensure that the terminal voltage does not rise much above 15 volts. The behaviour of the battery when extra loads, such as headlamps, are applied can give a useful guide to the overall condition of the battery and/or regulator circuit.

The offset zero voltmeter range is provided by using D18 to 'remove' 10 volts from the input potential. The load for the Zener diode is provided by R32, which causes a Zener

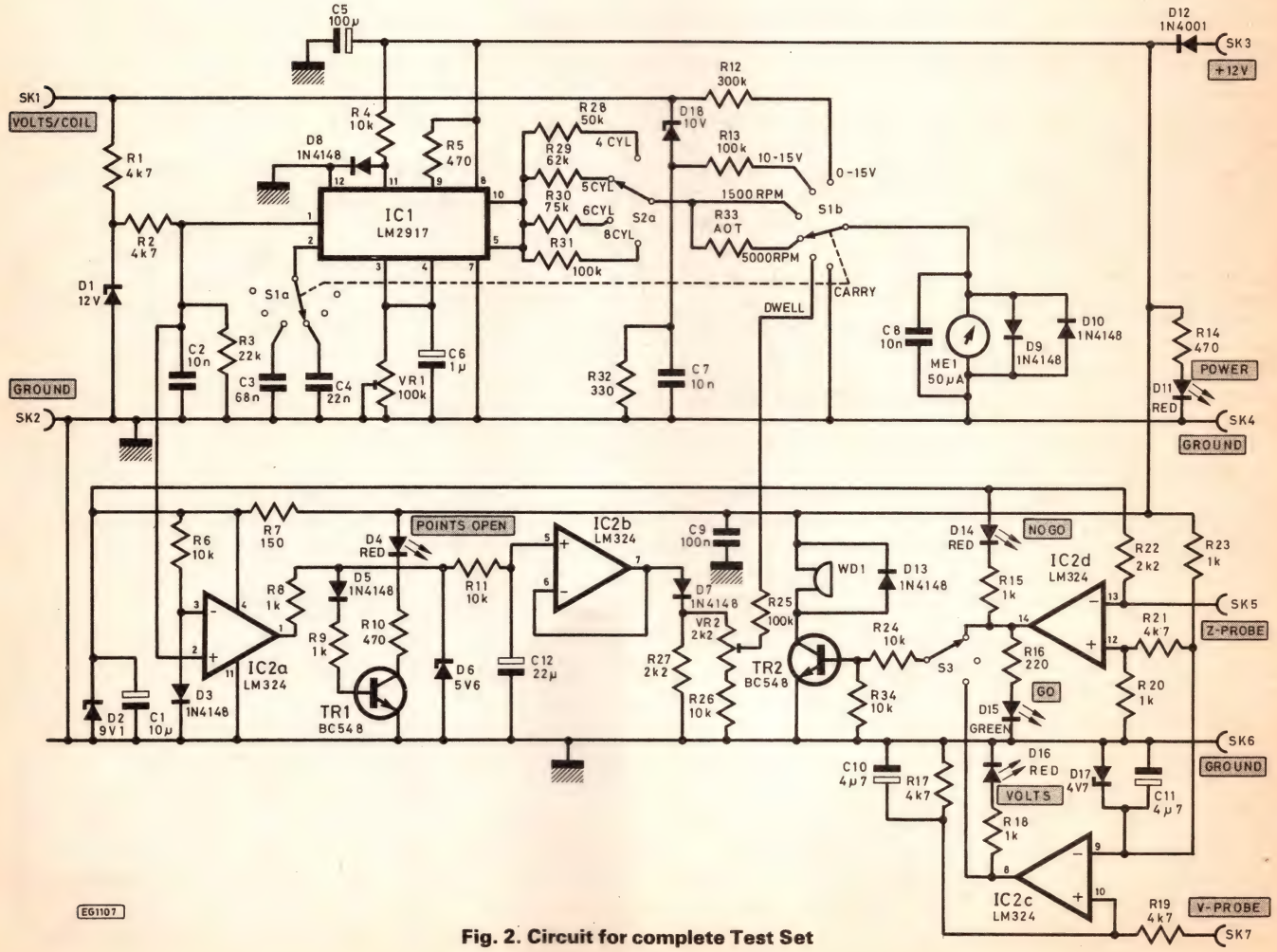


Fig. 2. Circuit for complete Test Set

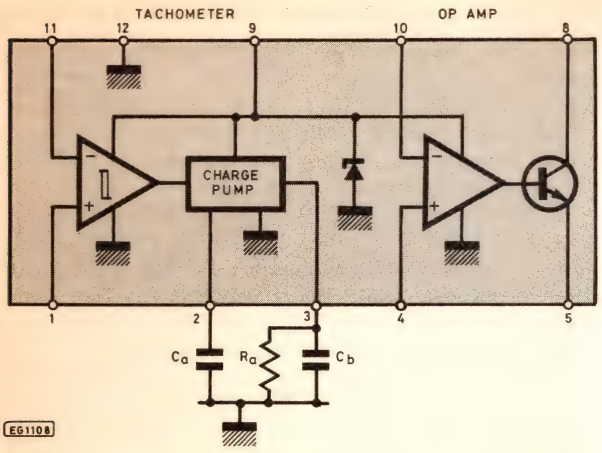


Fig. 3. The LM2917 frequency-to-voltage converter

current of approximately 10mA to flow at the expected operational mid-scale value. In practice, the calibration of the offset zero scale will not be perfectly linear, with the maximum errors at either ends of the scale, but this should not prove to be a great handicap since the greatest use of the scale is in the clear indication of variations.

TACHOMETER

During engine tuning, it is usually necessary to make certain measurements (e.g. ignition timing advance) at known engine speeds. The 'tickover speed' also needs to be carefully adjusted to the correct value; it should not be so high as to waste fuel at idle, but again it should not be so low that the car has difficulty in moving off smoothly when required.

The measurement of engine r.p.m. makes use, in the main, of the fact that the distributor shaft rotates at exactly half the speed of the crankshaft in a conventional engine. As a result, the ignition circuit produces a pulsed signal across the primary winding of the coil at a frequency of N pulses per minute, where N is given by the equation:

$$N = \frac{1}{2} \times \text{engine r.p.m.} \times \text{number of cylinders}$$

There are many ways in which the pulsed signal from the ignition coil may be sampled and converted to a voltage proportional to engine r.p.m., but the use of the National Semiconductor LM2917 i.c. produces one of the simplest circuits. The LM2917 is a linear monolithic device which contains a frequency-to-voltage converter, together with a high gain op amp/comparator designed to drive a relay or other external load up to 50mA. The tachometer section uses a charge pump technique and offers frequency doubling for low output ripple. Also provided in the i.c. is input protection, and an output which falls to ground level for a zero frequency input; in use the LM2917 has been designed to be easy to use.

The tachometer configuration of the LM2917 is shown in Fig. 3. A single RC network provides the frequency doubling, and the output voltage is simply related to the input frequency by the formula:

$$V_{out} = f_{in} \times V_{ref} \times R_a \times C_a$$

The integral voltage regulator sets the value of V_{ref} and this ensures accurate and stable conversion performance. The input stage is a differential amplifier in a positive feedback configuration. The flip-flop circuit allows the user to define the input switching level, while retaining the necessary hysteresis for good noise rejection. The charge pump then converts the input frequency, by now at a constant amplitude, to a d.c. voltage. The operation of the charge pump is determined by the timing capacitor, C_a, load resistor, R_a, and the filter capacitor. The filter capacitor determines the trade-off between output ripple voltage and the response time of the circuit.

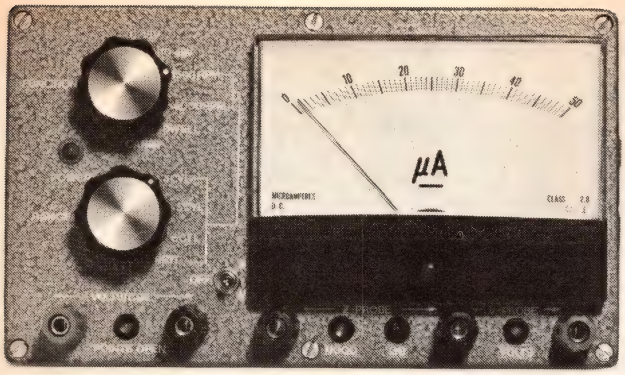
The circuit diagram for the complete tachometer is included in Fig. 2. The input from the ignition circuit is taken by connecting the volts/coil probes as shown in Fig. 4. The input signal at SK1 is then processed by R1, D1, R2, C2 and R3 to remove spikes and noise which may otherwise affect the operation of the LM2917. The input switching level of the voltage comparator within IC1 is set by the combination of R4 and D8; the level at pin 1 must exceed approximately 600mV before the comparator switches. The output at pin 5 of IC2 is determined by the signal frequency, the capacitor selected by S1a, and the setting of VR1. The response time of the circuit is set by C6; increasing the value will increase the response time, and vice-versa. The series resistor for the internal Zener regulator, R5, is chosen to minimise the reference voltage variation over a supply range of 9 to 15V. The calibration of the output for differing numbers of engine cylinders is achieved by S2, and the associated resistors, R26 to R31.

DWELL MEASUREMENT

The dwell angle of the contact breaker cam has a significant effect on the performance of an engine, particularly at higher speeds. Each vehicle has a specific dwell angle quoted for the distributor, and will have a value which depends on the design of the ignition circuit, and on the engine configuration. The distributor cam itself has a number of lobes, equal to the number of cylinders in the engine, symmetrically spaced on the shaft. The angular separation of these lobes will be 90°, 72°, 60° or 45° for engines with 4, 5, 6 or 8

SPECIFICATIONS

FUNCTION	RANGES	PROBE
Voltmeter	0 to 15 volts f.s.d. 10 to 15 volts offset zero	Volts/Points
Tachometer	0 to 1500 r.p.m. 0 to 5000 r.p.m. Both ranges may be used for 4, 5, 6 or 8 cylinder engines	Volts/Points
Dwell Meter	0 to 45°, 60°, 72° or 90° Calibration depends on the number of cylinders fitted	Volts/Points
Points State	An l.e.d. illuminates when the points are open	Volts/Points
Circuit Tracer	An l.e.d. illuminates when greater than 9·5 volts is present. Optional audible warning also available	V-probe
Lamp/Fuse Tester	GO/NO GO green/red l.e.d. indication of lamp/fuse state. Green shows resistance less than approx. 150 ohms. Optional audible warning.	Z-probe
Carry	The meter movement is shorted during carrying for safety	



cylinders, respectively. The actual dwell angle is defined as the angle through which the cam rotates whilst the contact breaker points are closed. The correct dwell angle for a particular vehicle will be found in the workshop manual, but is typically around two-thirds of the angle between the cam lobes.

The correct adjustment of dwell angle is often a matter which is left somewhat to chance; the more approximate measure of points gap is frequently used instead. To ensure correct combustion, however, it is the dwell angle which is actually the important factor in maintaining good performance and fuel economy. The angle must be large enough to allow the core of the ignition coil to become magnetically saturated, but not so large that the coil starts to overheat, eventually leading to breakdown. Too small a dwell angle, however, will result in a poor spark, and may cause overloading of the capacitor and burning of the points at low engine speeds.

Dwell angle is most easily measured by observing the duty cycle of the voltage waveform across the points. If the duty cycle is 100% (i.e. points open all of the time), then the dwell angle is 0°; conversely, if the duty cycle is 0% (i.e. points closed all of the time), then the dwell angle is equal to the angle between the cam lobes.

In general, duty cycle and dwell angle are related by the following formula:

$$\text{Dwell Angle} = \text{Cam Lobe Angle} \times \frac{100\% - \text{Duty Cycle}}{100\%}$$

The dwell measurement circuit, which is included in Fig. 2, makes use of two of the operational amplifiers in IC2. The contact breaker waveform is sampled by connecting the volts/coil probe as shown in Fig. 4. The waveform at SK1 is then filtered by R1/D1 to remove high voltage spikes, and by R2/C2 to remove high frequency noise. The filtered signal, which will have an amplitude of approximately two-thirds the input waveform, is then applied to the non-inverting input of IC1a. This amplifier is arranged as a voltage comparator, with the switching threshold set by R6 and D3. The overall effect is that the amplitude at SK1 must exceed approximately 1 volt to cause the output of the comparator to go high. The resulting comparator output is a rectangular waveform whose levels are limited only by the output saturation levels of the op amp itself; approximately 0·6V

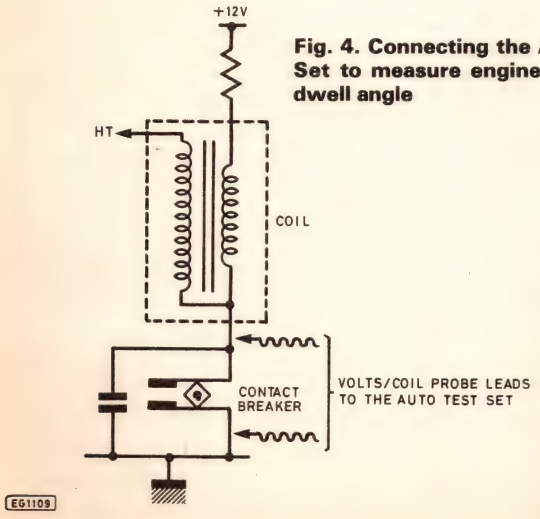


Fig. 4. Connecting the Auto Test Set to measure engine revs and dwell angle

COMPONENTS

Resistors

R1	4k7		R18	1k	
R2	4k7		R19	4k7	
R3	22k		R20	1k	
R4	10k		R21	4k7	
R5	470		R22	2k2	
R6	10k		R23	1k	
R7	150		R24	10k	
R8	1k		R25	100k	2%
R9	1k		R26	10k	
R10	470		R27	2k2	
R11	10k		R28	50k	2% (2 x 100k)
R12	300k	2%	R29	62k	2%
R13	100k	2%	R30	75k	2%
R14	470		R31	100k	2%
R15	1k		R32	330	
R16	220		R33	AOT (see text)	
R17	4k7		R34	10k	

VR1 100k horizontal preset
VR2 2k2 horizontal preset
All resistors 5% ¼W carbon types except where stated

Capacitors

C1	10μ 16V elect	C7	10n ceramic
C2	10n polyester	C8	10n ceramic
C3	68n polycarbonate	C9	100n ceramic
C4	22n polycarbonate	C10	4μ7 16V elect
C5	100μ 16V elect	C11	4μ7 16V elect
C6	1μ 35V elect	C12	22μ 16V elect

Semiconductors

D1	BZY88 C12V	D13	1N4148
D2	BZY88 C9V1	D14	Red l.e.d.
D3	1N4148	D15	Green l.e.d.
D4	Red l.e.d.	D16	Red l.e.d.
D5	1N4148	D17	BZY88 C4V7
D6	BZY88 C5V6	D18	BZY88 C10V
D7	1N4148		
D8	1N4148	TR1	BC548
D9	1N4148	TR2	BC548
D10	1N4148		
D11	Red l.e.d.	IC1	LM2917
D12	1N4001	IC2	LM324

Miscellaneous

SK1 to SK7 Panel mounting terminals to constructor's choice
Printed circuit board
Terminal pins
ME1–50μA large panel meter (Maplin RX54J)
Diecast box approx. 190 x 110 x 60mm
Ribbon cable
S1 2P 6W rotary switch
S2 3P 4W rotary switch
S3 SP on/off/on toggle switch—centre off
WD1 Piezoelectric or similar d.c. buzzer (RS 249–794)
Knobs (2 off)

(low) and V_{supply} — 1·2V (high). The dependence on supply voltage is eliminated by the clipper circuit made up of R8 and D6.

The average value of the processed waveform from IC1a is developed across C12, due to the integrating effect of R11/C12. A further op amp, IC1b, is arranged as a voltage follower to reduce the loading effects on the integrator circuit. The output low level saturation voltage from the buffer stage is removed by the action of D7, and the dwell circuit calibration is provided by VR2.

CONTACT POINTS STATE

The state of the contact breaker points is indicated by an l.e.d., D4, which is illuminated when the points are open. A switching transistor, TR1, is driven by the output of the voltage comparator stage in the dwell meter circuit.

CIRCUIT TRACER

Tracing wiring faults and broken connections in a vehicle wiring circuit must count as one of the more frustrating and

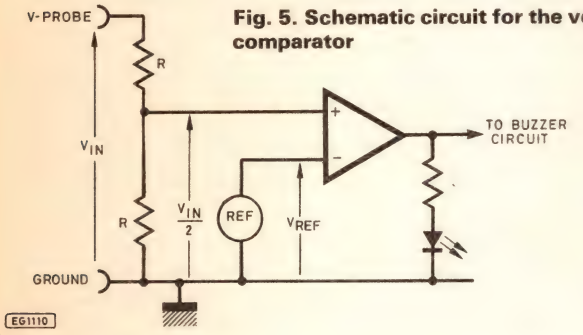


Fig. 5. Schematic circuit for the voltage comparator

tiring of diagnostic tasks. It is not so much that the job is difficult; it can, after all, be described as simply a matter of finding the point at which the voltage disappears.

A multimeter is understandably a natural first choice of diagnostic aid for the motorist with an interest in electronics. A few hours of crawling around under the dashboard, however, soon shows that it is no mean feat of skill to hold the two probe leads in position with one hand, while trying to operate the offending control with the other, and read the voltage on the meter.

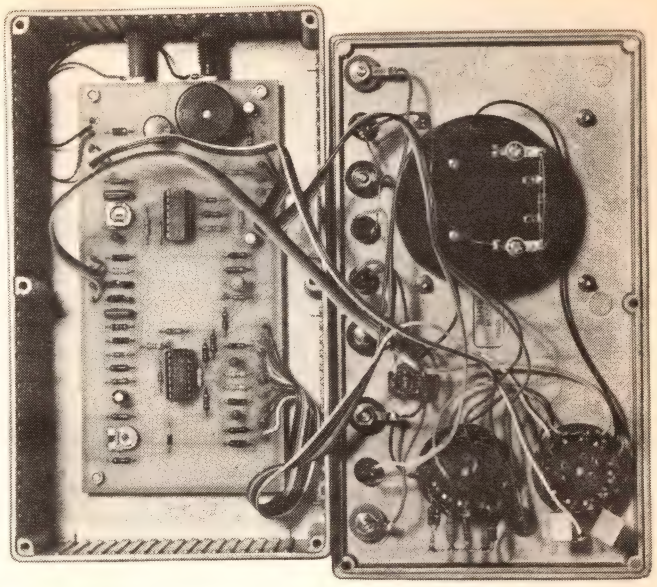
What is required is a test instrument which is more in tune with the requirements of the problem; simplicity is a prime consideration.

In circuit tracing applications the exact value of the voltage detected is of only secondary importance. The major point is to detect that the circuit is continuous up to the point being measured, since the usual cause of the problem is a dry joint, broken wire or faulty component. The significant effort in such fault diagnosis is to localise the fault as quickly as possible, and then more precise measurements may be made if required.

The circuit tracer in the Auto Test Set provides a simple indication of the presence of a voltage of greater than approximately $9\frac{1}{2}$ volts. The indication is permanently provided by an l.e.d., but an additional buzzer indication may also be selected.

The circuit tracer basically consists of a voltage comparator circuit driving a load of an l.e.d. and an optional buzzer circuit.

The general principles of the circuit are shown in Fig. 5. The circuit tracing probe is the V-probe; the potential present at the V-probe tip is attenuated by 50% by the



resistive attenuator, and then applied to the non-inverting input of the differential amplifier. The input to the inverting input of the amplifier is from a voltage reference source. The output of the amplifier is a saturated high level when the input voltage exceeds twice the reference voltage, thus turning the l.e.d. on. The buzzer circuit is arranged so that the buzzer is also on (if selected) when the amplifier output is high.

The voltage comparator circuit is built around IC2c, as shown in Fig. 2. The input attenuator is formed by R17 and R19, and the voltage reference source is provided by R23 and D17. With the component values shown, the l.e.d. D16 will be illuminated whenever the potential at SK7 exceeds approximately $9\frac{1}{2}$ volts; a buzzer will also sound if selected by S3.

LAMP/FUSE TESTER

Trouble-shooting in auto electrical circuits is a process which usually starts when some item of electrical equipment stops performing correctly. In many cases the symptoms are quite dramatic; one moment everything is running smoothly, and the next moment it has stopped. The most commonly encountered example of this abrupt change must surely be represented by the conventional filament lamp. The rectification of such a fault requires a realistic and methodical approach if an undue amount of time is not to be wasted; stories of changing the alternator to mend a fuse bear witness to the penalty which can be incurred by hasty diagnosis. The first step, and often the only one required, is to investigate the state of the non-functioning component, or at least the component which appears not to be working, before moving back to more remote ones.

The lamp/fuse tester is designed to provide a simple and easy-to-use "go/no go" indication of the state of simple electrical components. The tester can be used to examine the state of lamps, fuses, wiring, switches, relays, and indeed almost any passive electromechanical component. To assist in circuit tracing, particularly pin-pointing wiring breaks, a "go" result may also be used to activate the audible warning.

The lamp/fuse test circuit consists basically of an impedance comparator circuit which illuminates one of two l.e.d.s and an optional buzzer circuit. Which of the two l.e.d.s is illuminated is determined by whether the impedance

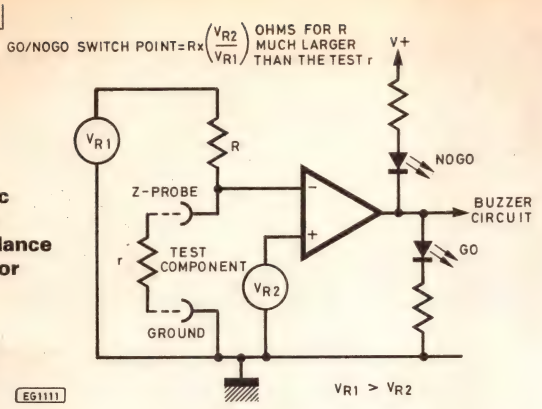


Fig. 6. Schematic circuit for the impedance comparator

between the Z-probe and ground is greater or less than the preset threshold. The general principles of the comparator are illustrated in Fig. 6. From this circuit, it can be seen that when there is no test load, the output level will be low, thereby illuminating the "no go" l.e.d.; conversely, when the test load is a short circuit, the output will be high and will cause a "go" indication. The switching point, i.e. the impedance for test load below which a "go" indication will be obtained, is determined by the two reference voltages and the value of R.

The lamp/fuse tester is built around IC2d, as shown in Fig. 2. The reference input to the non-inverting amplifier terminal is provided by an attenuator across the reference diode D17; this results in a reference of just under a volt. The other reference supply for the inverting input is provided by R7 and D2, and is at a level of 9·1 volts. The value of R22 sets the switching level of the comparator, in conjunction with the two reference levels as shown in Fig. 6, to approximately 150 ohms. This value has been chosen as it represents the on resistance of a 1 watt automotive bulb, and as such represents probably the highest correct resistance likely to be met in practice.

Next month: Constructional details, testing and calibration will be presented.

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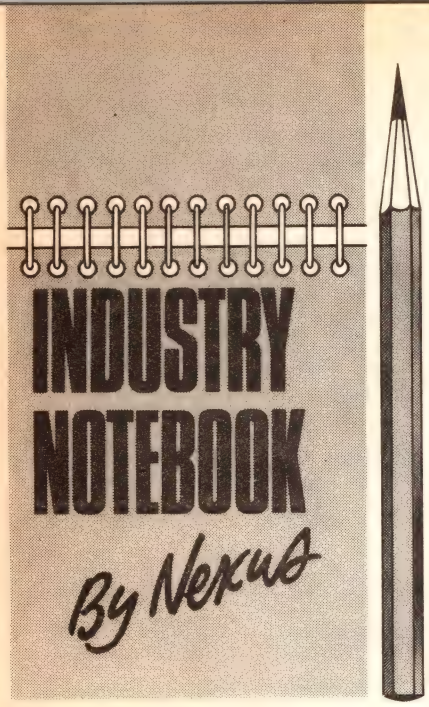
PE BAZAAR MAY '83



The Goonhilly Show

It seems incredible now that only a little over a decade ago few people had ever heard of Goonhilly. An unlikely, even comical, place invented perhaps by the Goons themselves or even earlier as a setting in a Wodehouse novel. Instead it turned out to be a very real piece of real-estate in Cornwall. In the summer of 1962 Goonhilly Downs emerged from obscurity to become world famous. But even then few of us glued to our tubes to watch the first ever live transatlantic TV transmission via communications satellite realised the speed at which the new technique would become established.

Goonhilly today is not the only satellite earth terminal site in the UK but it remains the largest and, commercially, the most important. The addition this year of Goonhilly 5, the fifth big steerable dish in the complex, marks yet a further stage of expansion.

The new terminal is dedicated to maritime communications. The concept is not new as the first shipborne terminals were fitted in 1976. But take-up of the maritime satellite service has been painfully slow so that after some seven years there are only a little over 1,500 installations in service. This is mainly due to the ingrained attitude of many shipowners who regard the ship's radio room and its operator(s), mandatory by international law for safety reasons, as an imposed overhead expense. Why go beyond the minimum requirement? Add to this the unhappy plight of world shipping in a trade recession and there is even greater reluctance to spend money on what could be senseless extravagance rather than prudent investment.

Goonhilly 5, like its predecessors, was built by Marconi and is owned and operated by British Telecom who, in their newly acquired competitive spirit, have put together a sales package which could break through the apathy of shipowners. What BT is offering is direct dialling ship-to-shore telephone links between most destinations in the world at a cost of up to 50 per cent less than the already established service from the United States. Goonhilly 5's global coverage embraces about 80 per cent of the world's shipping and offers total communications reliability round-the-clock, vastly superior to ordinary ship's h.f. radio with its diurnal variations and ionospheric disturbances.

At present the rate of new shipborne installations is running at about 40 a month. It is estimated that by the end of this decade some 12,000 ships will have been fitted. This has to be good for business and good for shipowners, too. Of course the shipowners are still counting their pennies, with most of them anxiously monitoring their overdrafts, but shipping economics today are more than ever dependent on productivity. A tide lost or a cargo missed is big money. Instant and reliable communication can tip the balance from loss to profit. So the sales pitch is not whether a shipowner can afford it but whether he can afford to do without it.

The Big Fight

As I write there is no firm date for the forthcoming big fight. Both the main contestants are, however, in training with broad strategies defined, tactics to be decided much nearer the day. The champions in the blue corner might be described as political realists, the challengers in the red corner as political dreamers. The realists are favourite in the polls but the odds could and often do shift unpredictably. How will the result affect industry?

On the industrial front the main issue of principle between the two major parties is nationalisation and private enterprise. If we take history as a guide there will be no clear cut victory. Whatever might be said on either side, even written into manifestos, there has always been a compromise. No Labour government has killed off private enterprise, no Conservative government butchered nationalised industry. The mixed economy is here to stay although the balance of mix may change. In the end all is compromise with Labour pouring money into private industry when in office and Conservatives pouring ever-growing amounts into failing State-run industries.

On the broad economic front Labour's biggest punch, a straight left, is unemployment, supplemented by body blows on defence and withdrawal from the European Common Market. Such a combined attack could floor the Conservatives if only because it has great emotional appeal. But if the knock-out takes place what will subsequently happen in practice is very unlikely to be that predicted in rhetoric. Labour cannot significantly reduce unemployment without distorting the economy. On defence, in particular on disarmament, semantic experts are working as I write on a form of words which will declare a unilateral stance on nuclear weapons within a multilateral context, which will commit nobody. On the Common Market the policy will be to withdraw in theory but remain in practice through a "re-negotiation".

The most effective punch from the defending champion is low inflation, the pound in your pocket being worth very nearly as much next year as it is today. This will be backed by a less than normally vicious budget (already announced) and the undeniable fact that people still in work, the silent majority who are not dramatically newsworthy, have never had it so good.

Paradoxically the blue policy, so objectionable to the red corner, is the very one they were advocating in October 1964 when they set up the new Ministry of Technology "to guide and stimulate a major national effort to bring advanced technology and new processes into British industry". Mintech was to be the vehicle for obtaining improved economic performance and improved competitive power. By 1969 Mintech had a staff of 36,000 dedicated to the ideal. In the event every innovation was bargained over, resisted as long as possible. A transition which could have been achieved smoothly over two decades has had to be compressed into the past four years at the worst possible time in world trade with consequent unnecessary pain.

No, I haven't forgotten the Liberal/SDP alliance. In the event of no decision the alliance will, in effect, become a biased referee favouring one side or the other. The alliance is itself a compromise but on withdrawal from the ECM and the nuclear question they are more blue than red.

So, unless the extremists of either persuasion come unexpectedly from behind, there won't be much change.

More Showbiz

It was perhaps inevitable after all the ballyhoo in 1982. Anyway, here it is folks, the first ever International Conference and Exhibition on Satellite and Cable TV in Europe. Or Cable '83 for short. It will be held at the Wembley Conference Centre with over 50 authoritative speakers from the UK, Europe and North America.

The organisers, Online Conferences Ltd already have a track record in other IT areas and have used every emotive word and phrase they can think of to promote the event. Thus we have a scene which is "explosive and complex" but nevertheless calls for "an adaptive sensitive approach" in what is clearly "a dynamic situation".

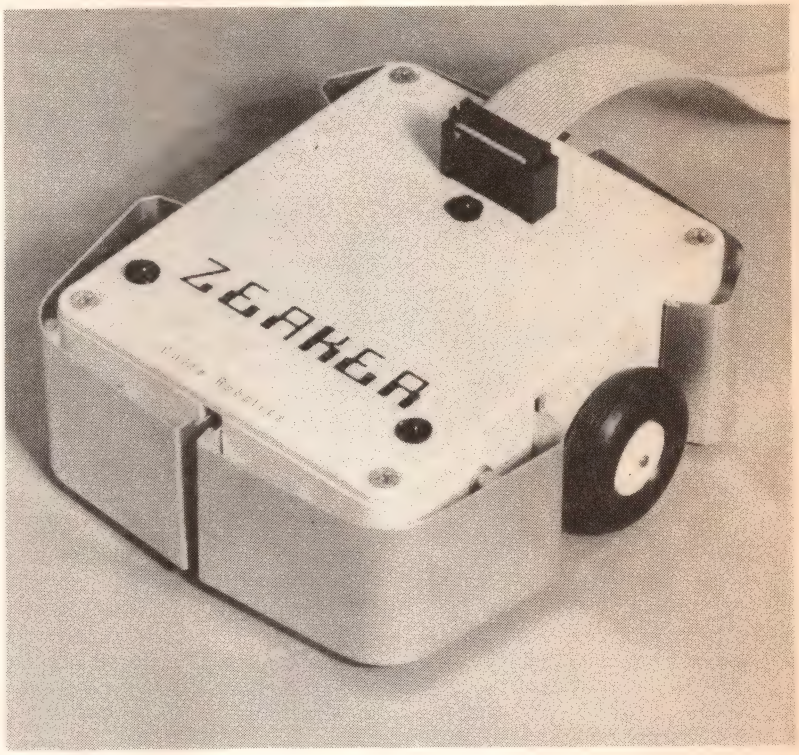
I was especially intrigued by some of the conference topics. Under the heading of Marketing the question is posed, "Broadband-moneyspinner or black hole?" Under Direction we are promised a discussion on "The franchising jungle". Under the heading of Issue Areas the no doubt vital issue is "Go-go or go-slow". Again under Marketing there are talks on "Entering and surviving" and another question, "What follows the movies?"

The organisers say with evident satisfaction that there are likely to be few restriction on Cable TV programme content, even fewer on imported material, and that cabling the UK alone will shift £2·5 billion into pockets of the participants. So roll up, roll up! How to win in this brand new game will all be explained from 10–12 May. A game? It must be. The advance billing says plainly "The major players are already jockeying for position". Ughh!

HERE AT LAST !
A Micro-Mobile you CAN afford !

INTRODUCING ZEAKER

A PE-COLNE ROBOTICS PROJECT

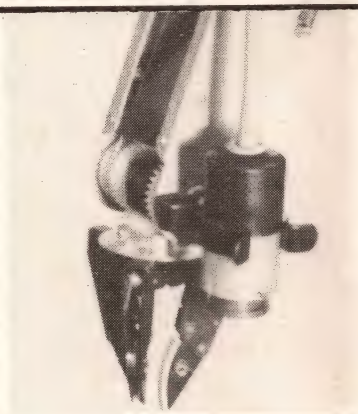


Colne Robotics brings you the ZEAKER MICRO-MOBILE (as featured in this month's construction project), a low-cost mobile robot for use with microcomputers. It's compact (5×5×2") and rugged, with two separately-driven DC motors powering its wheels. Eight touch sensors indicate collision with obstacles to the computer, which can then instruct ZEAKER to take evasive action. Touching an obstacle triggers a two-tone alarm horn which changes in pitch according to direction of travel. A retractable pen, controlled by the computer, is provided to enable ZEAKER to trace its path and, if provided with appropriate software, produce logo graphics. LEDs indicate direction of motion and pen status, and with its two metres of umbilical ribbon cable ZEAKER can roam over any flat surface. Drive ZEAKER with any microcomputer fitted with an 8-bit bi-directional port (ZX81/SPECTRUM users note – we can supply a special interface).
Complete with power supply, operation manual and basic software, ZEAKER is available at the special introductory price of only £59.95 (kit) or £79.95 (assembled) including VAT.

OTHER EXCITING LOW-COST ROBOTIC PRODUCTS

ROBOT VISION

COLVIS is a low-cost vision system which is able to see objects and remember their shapes! Its powerful, Z80-based dedicated microcomputer extracts information from the image produced by a 1024 (32×32) pixel solid state camera which is light enough to be mountable on the end of a small robot arm. Features of the image, such as area or hole count, can be remembered and used to recognise subsequent objects viewed. The system can also determine the position and orientation of an object and may be used either on its own or as an intelligent peripheral to any computer fitted with an 8-bit bi-directional port.
COLVIS costs only £395 (+ VAT and excluding T.V. monitor and cassette recorder).



THE COLVIS CAMERA FITTED TO THE END OF AN **ARMDROID** ARM

THE ARMDROID MICROROBOTIC-ARM

Meet ARMDROID I, the robot arm which has made Colne a world leader in micro-robotics! It can be driven by any micro-computer which has (or can be fitted with) an 8-bit parallel port, and comes complete with software which enables a sequence of moves to be 'learnt'. Available in either kit or assembled form, ARMDROID I reproduces the actions of full scale industrial robots at a fraction of the cost. This precision, stepping-motor driven arm which has become an industry standard in education and industrial training, is now available to the hobbyist for between £300 and £600 (depending on options chosen).

I AM INTERESTED IN YOUR PRODUCTS AND WOULD LIKE FURTHER DETAILS OF: *Tick as appropriate

☐ ZEAKER ☐ COLVIS ☐ ARMDROID

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.....

COLNE ROBOTICS Co. Ltd.

BEAUFORT RD., OFF RICHMOND RD., EAST TWICKENHAM TW1 2PH

ZEAKER
MICRO-ROBOT
PART 1

DAVID BUCKLEY

ZEAKER is a small, low cost computer controlled robot vehicle designed to have all the normal functions of a "turtle" i.e. steering, lights, pen, horn and bump sensors but it is also capable of being expanded using photosensors for eyes to seek out or avoid light or to follow white lines etc; with a complex sound generator for special noises à la R2D2, and with computer speech.

It will easily interface to most popular microcomputers and can be programmed in a high level language like BASIC, although a modular language like FORTH or PASCAL would be better.

Under program control Zeaker can go forward, backwards or rotate right or left on the spot; it has two navigation lamps: port and starboard (or eyes if you prefer) which can be turned on or off; a speaker which can emit a high or low tone or a combination of both; 6 tactile sensors which can detect a collision with an object in Zeaker's path and finally but not least a pen which can be lowered or raised to enable Zeaker to draw Turtle Graphics. The up or down state of the pen is indicated by a lamp on the top of Zeaker.

Zeaker was designed to run on a table top, but will also run on smooth floors and because of this and to keep down the cost, the controlling electronics and power supply are contained in a separate box linked to Zeaker by a 2 metre umbilical cord (16 way ribbon cable). This separate box ('Zeaker Control Station') is linked to the microcomputer by two short ribbon cables.

DESCRIPTION OF ZEAKER (VEHICLE)

Zeaker's chassis is a modified ABS plastic box inside which are two electric motors complete with gearboxes, one driving each of the two wheels, a small speaker for the horn and a solenoid to lower the pen.

Mounted in the lid of the box are the navigation lamps, or eyes (red and green l.e.d.s), the socket (SK1) to connect the umbilical cord and the pen status l.e.d. (yellow) whilst on the outside are the four Aluminium Fenders which when touched compress foam plastic blocks and make contact with screw heads in the side of the box, thus forming 16 simple switches which are paralleled into 6 groups (Fig. 11). Underneath at the front is a plastic "toe" to give Zeaker stability.

DESCRIPTION OF ZEAKER CONTROL STATION

The Control Station contains 4 Nicad C-cells to provide the power for Zeaker. This eliminates all the safety problems with mains powered equipment and thus it may be left without fear in the hands of the youngest child. Using Nicads also leads to a more compact power supply unit and a fully charged set will power Zeaker for at least 4 hours but including thinking time, human's and Zeaker's, this will easily stretch to 8 hours. To recharge the Nicads the computer's power supply can be used, in the version here, the ZX–81 power supply simply plugs in the back and trickle charges the Nicads through a lamp which also acts as a reminder that the supply is on. The ZX–81 power supply will recharge the Nicads overnight.

A printed circuit board holds the driver transistors which switch on the motors, lights and solenoid. A 556 dual oscillator is used to provide the tones for the horn whilst a 74LSOO Quad NAND i.c. wired as a set/reset latch prevents the motors being switched into reverse as well as forward. On the front panel is a switch which isolates the control electronics from the Nicads and acts as an "off" switch for Zeaker. No robot (leastways with present technology) should be without an "off" switch.

VEHICLE CONSTRUCTION

First, the box should be modified as shown in Fig. 1, then the metal Fenders should be made and bent to shape using the template drawings in Fig. 2. The solder tags should be attached as shown in Fig. 3 and the bends checked again. Make up the pen arm and bracket (Fig. 4), once again this drawing can be used as a template for bending the pen arm. A corner of one of the motor gearboxes (Fig. 5) should be removed. (This will be the starboard motor assembly.) The motors and gearboxes should be assembled using only 4 of the black plastic gears with the long end of the small motor shaft shortened so the shaft is 39mm in length. Next press on the white gear wheel and put on the spacers. Assemble the gearbox and secure the end cap with polystyrene cement (for plastic kits) (Fig. 6).

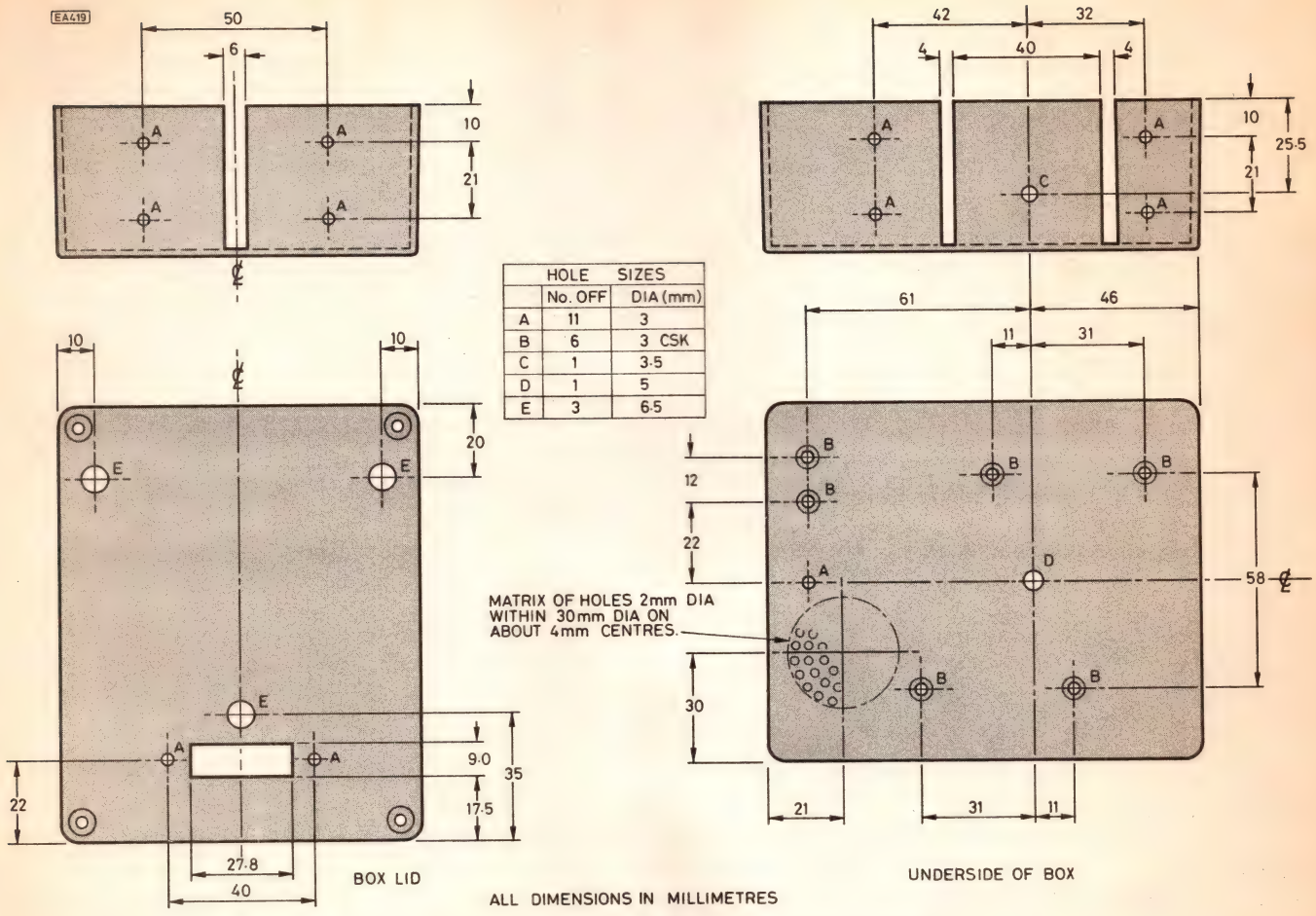


Fig. 1. Cutting and drilling details for Zeaker's chassis

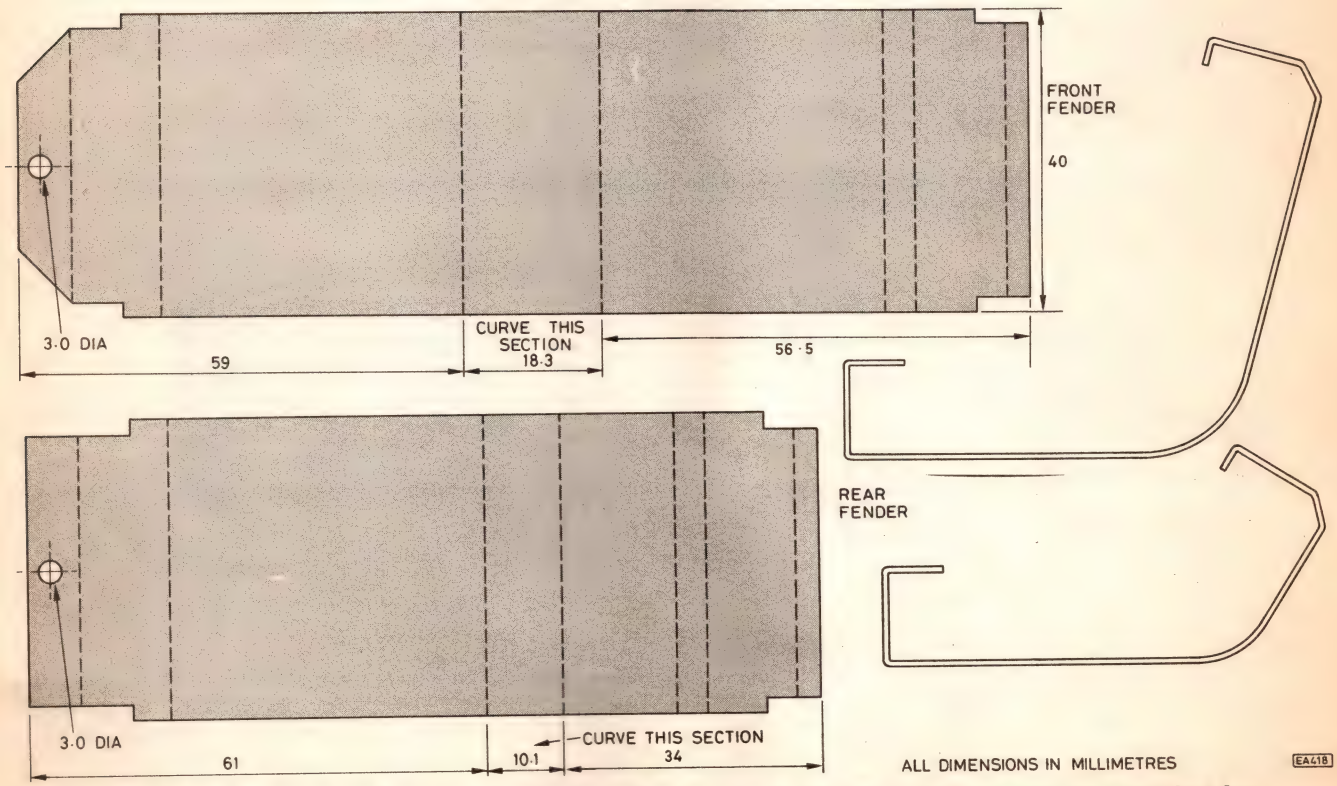


Fig. 2. Fender cutting and bending details. Note this drawing is full size and can be used as a template for cutting and bending the fenders

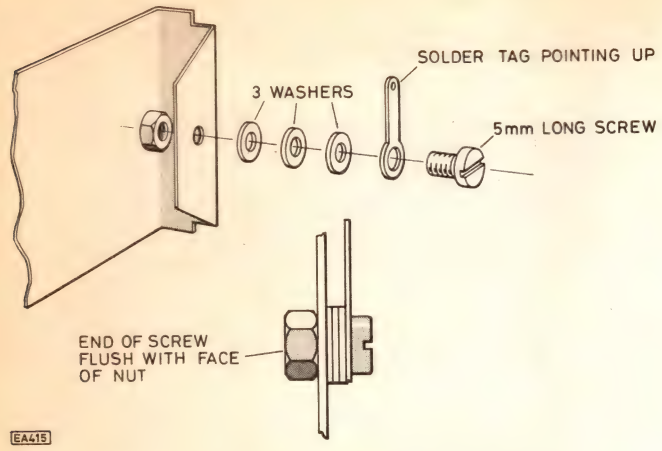


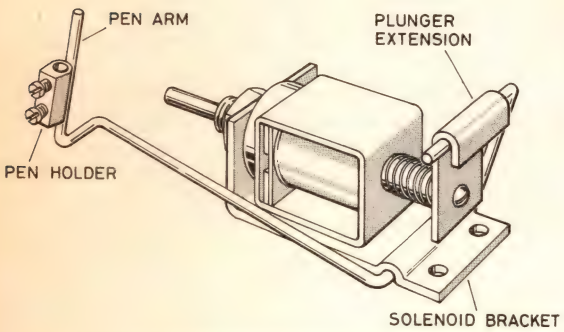
Fig. 3. Method for attaching solder tags to fenders

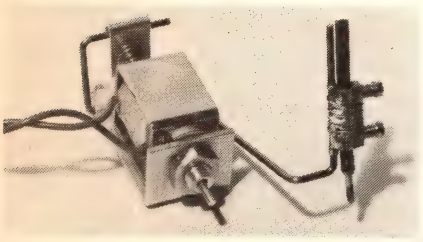
the solder tag and the toe components fitted to hold the speaker (Fig. 8).

The left motor assembly can now be positioned checking that it doesn't bind. Now assemble the solenoid in its bracket, fit the plunger extension and spring (Fig. 4) and bolt the bracket to the bottom of the box fixing the pen arm underneath. The pen arm should be loose enough to move freely under solenoid control. Fit the pen and make sure that it is centred in the hole at the bottom of the box, adjusting the bracket position accordingly.

A fibre washer should be placed on each wheel shaft and then the wheels can be fitted (Fig. 6). Adjust the pen in its holder so that in the down position it projects about 1 to 1½mm below the bottom of the wheels. The pen can then be shortened so that its top is level with or just below the top of the pen arm.

The Fenders should just drop in the slots of the box, after being eased over the foam pads. They should push in and make contact with the pillars very easily and the foam pads should spring them out again.





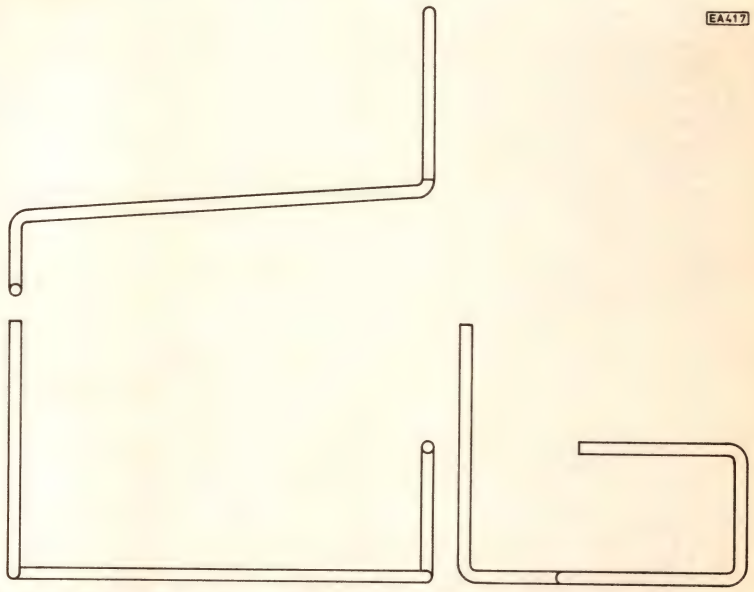


Fig. 4. Solenoid mounting bracket and pen arm. Note the pen arm drawing is full size and can be used as a template for cutting and bending the arm

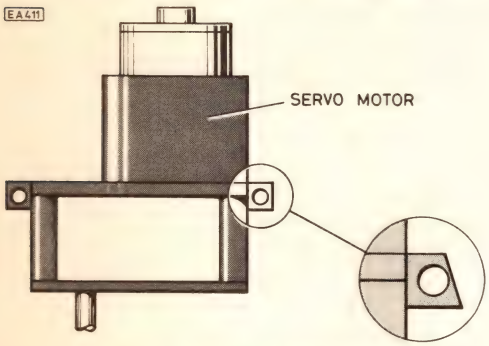


Fig. 5. Servo motor modification

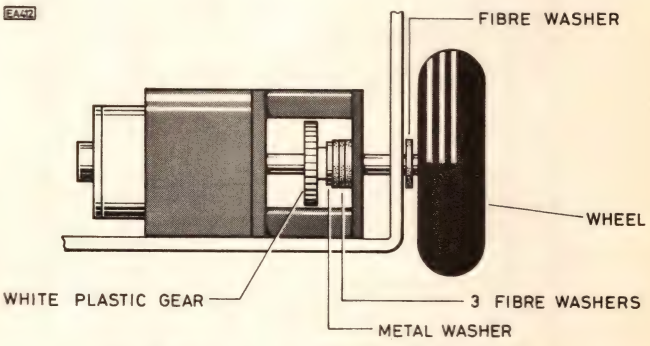


Fig. 6. Motor, gearbox and wheel assembly

The tactile sensor screws and pillars should be fitted next (Fig. 7 and Table 1) and then the foam pads can be mounted as shown in the photograph. The starboard motor assembly should be bolted into position and a solder tag fitted on top of the front mounting lug to hold the speaker in position. Check that the output shaft does not bind on the sides of the case hole. The speaker can now be fitted in position under

VEHICLE PCB

The vehicle p.c.b. is shown in Fig. 9 with the component layout shown in Fig. 10. The components are mounted on the solder side of the board with the exception of SK1. Before fitting the components, solder should be run onto each square pad to form solder bumps. The diode, resistors and RF chokes should then be soldered, blobbing the ends of

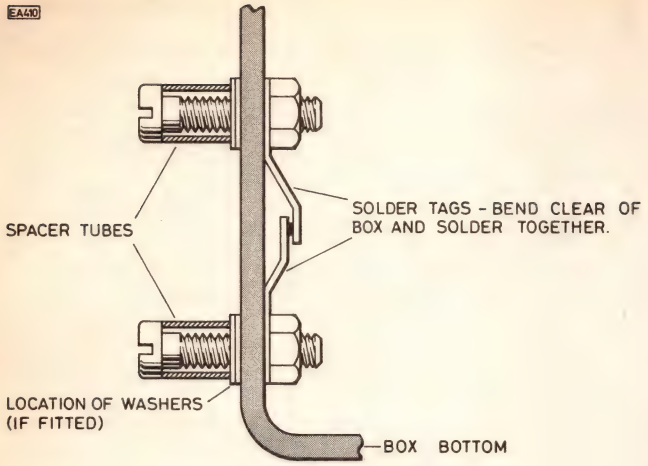


Fig. 7. Tactile sensor contact assembly

Top and bottom contact points are identical

LOCATION	SPACER LENGTH
Front	3mm
Side front	7mm (6mm spacer + 2 washers)
Side rear	6mm
Rear	3mm

Table 1

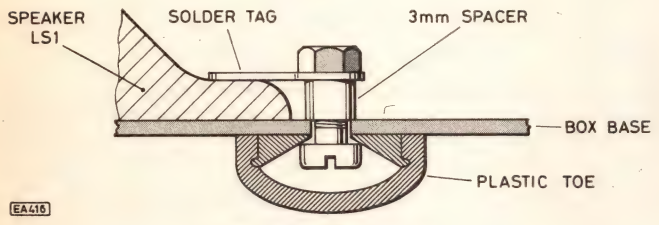


Fig. 8. Toe assembly

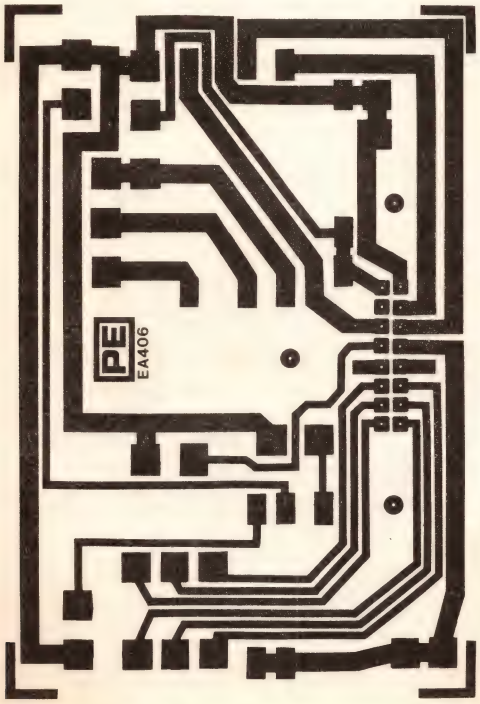
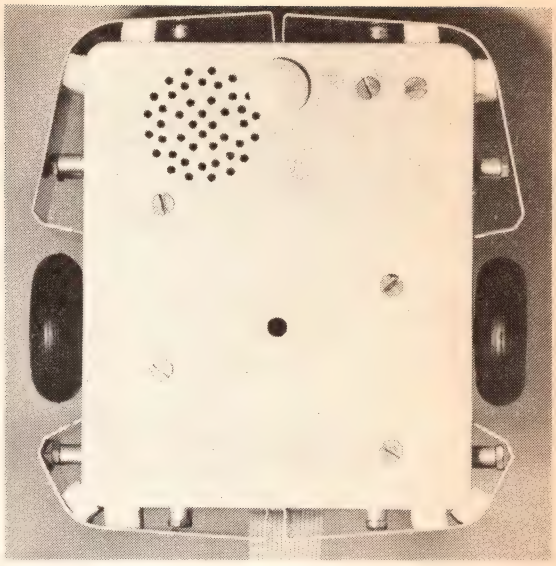


Fig. 9. P.c.b. for vehicle



Photograph showing the position of the foam pads

the leads into the solder bumps (Fig. 10). The 16-way Molex connector (SK1) should be fitted from the opposite of the board and soldered in place.

The p.c.b. should be bolted onto the lid of Zeaker using two fibre washers over the p.c.b. tracks. The l.e.d.s and link wires to the p.c.b. can be soldered next with the leads of the centre l.e.d. bent down and soldered to the two adjacent pads.

VEHICLE WIRING

All the top and bottom solder tags on the contact-points should be linked as should the side-rear and rear contact-

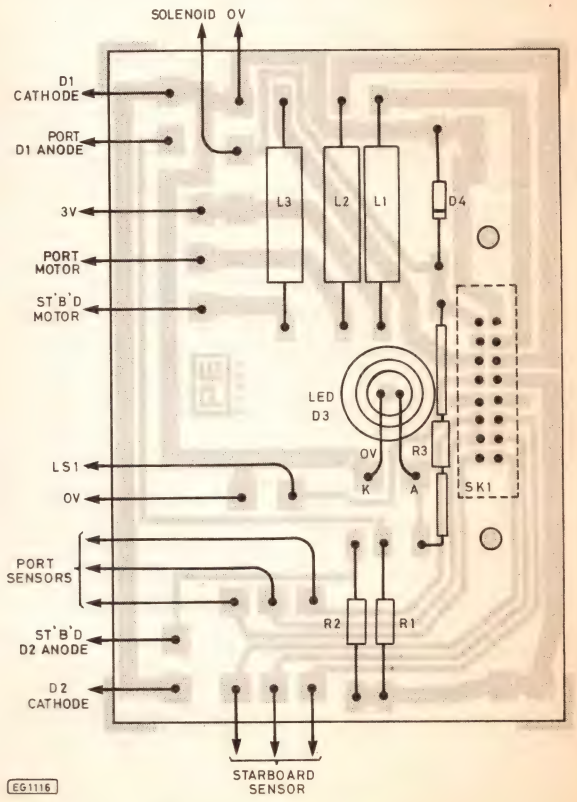


Fig. 10. Component layout

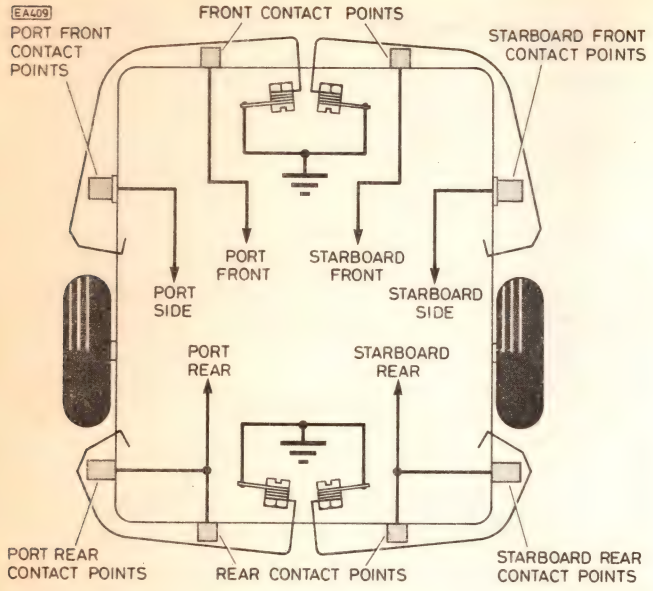


Fig. 11. Location of Zeaker's tactile sensors

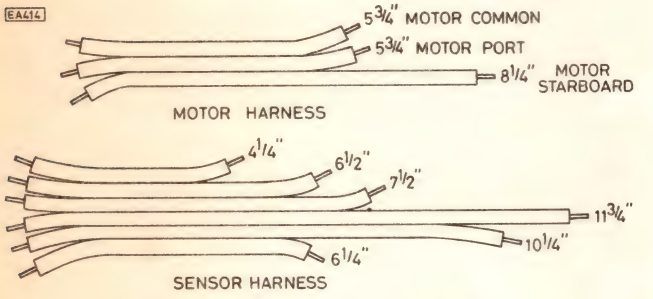


Fig. 12. Motor and Sensor harnesses

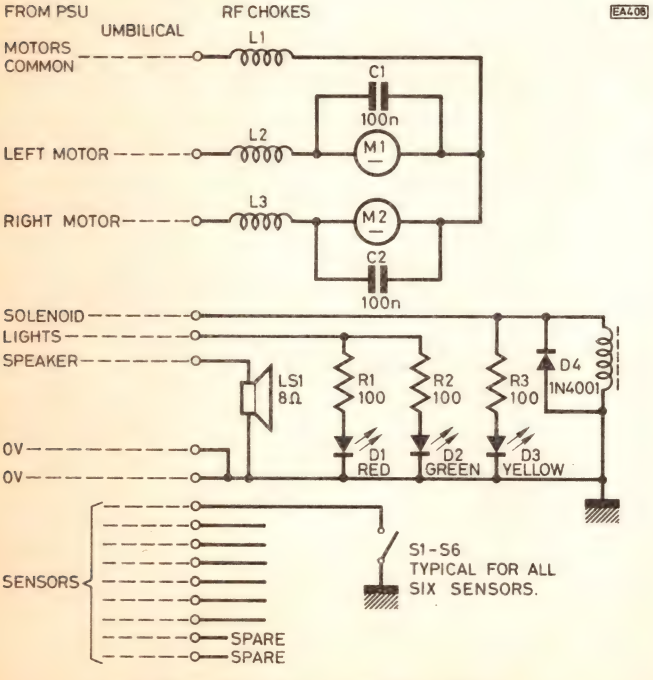


Fig. 13. Wiring diagram for the vehicle

COMPONENTS . . .

VEHICLE

Resistors

R1, R2, R3 100 (3 off)

Capacitors

C1, C2 100n (2 off)

Semiconductors

D1	0·2 in red l.e.d.
D2	0·2 in green l.e.d.
D3	0·2 in yellow l.e.d.
D4	IN4001

Inductors

L1, L2, L3 Lamp RF chokes (3 off)

Miscellaneous

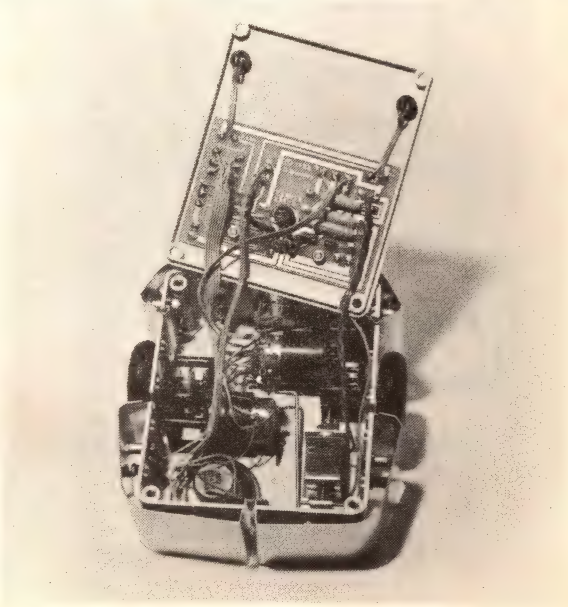
ABS plastic box (120 x 100 x 45mm)
Cover cap for toe
Micro Mold 38 x 13 wheel (2 off)
Como motors and gearboxes, small (2 off)
Keyswitch Varley 5V solenoid SM00
1½in. dia. 8 ohm speaker
Pen holder—centre from 5A connector block
Clips for l.e.d.'s (3 off)
Molex connector 5332 series 16 pin
Aluminium for fenders, plunger extension and solenoid mounting bracket
Rod for pen arm
Fender foam pads (self-adhesive draught excluder)

Constructor's Note

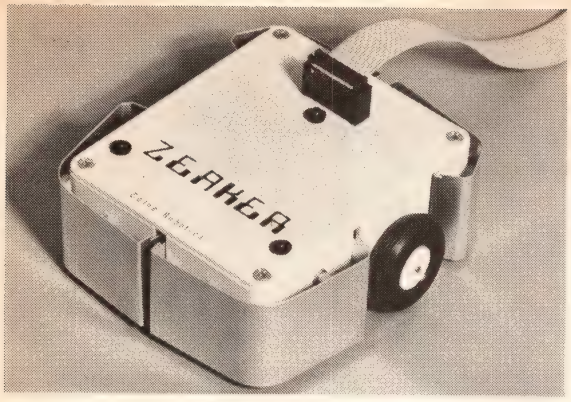
The toe cover cap is available from most hardware stores and the wheels and motor gearboxes assemblies are obtainable from hobby shops.

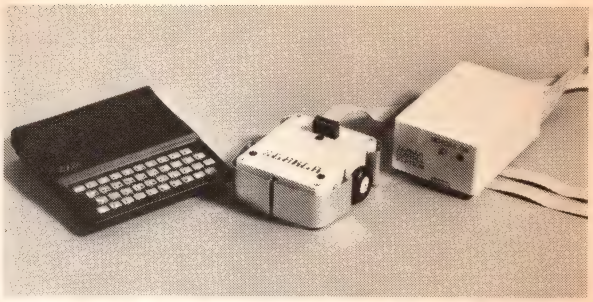
A complete kit of parts for the vehicle (including machined, cut and ready bent items) and control station with a manual and software is available from Colne Robotics Ltd., Beauford Road, off Richmond Road, Twickenham TW1 2PH (01-892 8197/8241). Price £59·95 inc. VAT.

Colne Robotics are also able to supply the separate parts, please write or phone for details.



Internal view of the vehicle





The Zeaker Vehicle together with its Control Station and a ZX-81

FORWARD

STARBOARD								PORT
SENSOR PORT FRONT	SENSOR PORT SIDE	SENSOR PORT REAR	SENSOR SPARE (a)	SPEAKER	MOTOR STARB'D	MOTOR COMMON (2·5V)	SOLE-NOID	
1	3	5	7	9	11	13	15	
SENSOR STARB'D FRONT	SENSOR STARB'D SIDE	SENSOR STARB'D REAR	SENSOR SPARE (b)	LIGHTS	MOTOR PORT	MOTOR COMMON (2·5V)	0V	
2	4	6	8	10	12	14	16	

CABLE CHANNEL

Fig. 14. Molex connector pin allocations (viewed from copper side (below) of p.c.b.)

points (Fig. 11). The 6-way harness can then be fitted to the contact-points starting with the longest lead at the Front Port contact-point and then fit the speaker harness, finish the interwiring and fit the motor harness. Then slot the fenders into position and solder the fender links. Finally solder the harnesses to the appropriate pads on the p.c.b. (Fig. 13). The solenoid leads should be cut to $5\frac{1}{4}$ inches, twisted together and soldered into place on the p.c.b. Check that when the lid is shut none of the wires foul the fenders and that they can be pushed in to make contact as before.

VEHICLE CHECKOUT

Using a signal/pin allocation diagram (Fig. 14) check with a multimeter that each of the sensor lines is shorted to 0V when the appropriate contact pillar meets the fender and that upon release there is an open circuit. Apply +5V to the solenoid pin and check that the solenoid clicks in and lowers the pen, similarly check the lights with +5V. Applying 2V ($1\frac{1}{2}$V will do) between motor common and the motor lines check that +ve voltage on the port motor line makes the motor go forward and —ve makes it go in reverse and check that a +ve voltage on the starboard motor line makes it go back and —ve makes it go forward i.e. to go forward port line is +ve and starboard line is —ve (to even out battery use).

NEXT MONTH: Control station construction.

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MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

MANY microcomputers now offer programming languages such as FORTH, PASCAL, and LISP as alternatives to the ubiquitous BASIC which has become established as the universal programming language of micros. This month's Micro-Bus takes a detailed look at one of these (LISP) and the advantages it offers over BASIC for certain applications.

LISP

The most apparent difference between LISP and BASIC is the way programs are written. In BASIC the program is written as a number of statements which can be listed, edited etc; this is then RUN to perform the desired actions. In LISP the programming consists of defining 'functions' which have exactly the same status as the functions which constitute the language itself. For example, PLUS is a function provided in LISP for performing addition; the programmer can define a function ADD which behaves in exactly the same way as PLUS, or indeed can re-define PLUS to do something different (as shown later in this article).

ATOMS AND LISTS

The nuts and bolts of LISP are very simple when compared to BASIC. Whereas in BASIC there are variables, arrays, functions, subroutines, and language statements, in LISP there are just two fundamental types of object: atoms and lists. The atoms are indestructible units, such as numbers like 23, or symbols like NAME, PROG1, etc. Lists are composed of atoms, and a simple list of three atoms might be:

(RED WHITE BLUE)

where the brackets are used to enclose the elements of the list. Lists may be composed of any number of atoms, or other lists; for example:

(16 (THIS))

is a list of two elements, the atom 16 and the list (THIS).

Symbols can have values, so they act like the variables of other languages. Normally anything typed at the keyboard of a LISP system is evaluated, and as a reminder of this LISP's prompt is:

Evaluate:

So if we type an atom, such as:

Evaluate: LINEWIDTH

we are given its value in return:

Value is: 40

The value could be a number, a symbol, or a list. Note that evaluating a number just gives the same number.

FUNCTIONS

A symbol can also be designated as the name of a function; we have already met PLUS, the LISP function for performing addition. How then do we call a function? The answer is that we first construct a list starting with the function name, and followed by the list of arguments that the function needs. Then we ask LISP to evaluate that list. Thus to add 2 and 3 we type:

Evaluate: (PLUS 2 3)

And the answer comes back:

Value is: 5

Arguments to functions are normally evaluated before being passed to the function, so we can write:

Evaluate: (PLUS (TIMES 1 2) (TIMES 4 6))

to find the answer to 1*2+4*6.

In addition to all the usual built-in functions, LISP contains functions for manipulating lists. The three most important ones are CAR and CDR (the names are historical) which break down lists, and CONS which constructs a list.

CAR returns the first element of a list, and CDR returns the list with the first element removed. Thus, suppose LIS had the value:

(ONE TWO THREE)

then (CAR LIS) would give ONE
(CDR LIS) would give (TWO THREE)
(CAR (CDR LIS)) would give TWO
(CDR (CDR LIS)) would give (THREE)

CONS takes two arguments, the second of which must be a list; it adds the first argument to the front of this list. Thus:

(CONS 4 LIS)

is (4 ONE TWO THREE).

Although arguments to functions are normally evaluated, one can prevent this by using the QUOTE function, which can be abbreviated . . . Thus:

(CAR '(ONE TWO THREE))

would give ONE as before. However:

(CAR (ONE TWO THREE))

would normally give an error because ONE is not a valid function.

So far we have not discussed how values are assigned to atoms. Again, this is by means of a function; the function, SETQ, takes two arguments, and the value of the second is assigned to the first. Thus:

(SETQ NO 4)

would give NO the value 4. (Note that this is one function that does not evaluate its first argument.)

We now need to look at the COND function which gives LISP conditional facilities. Consider the following example:

```
(COND
   ( (EQ VAL 1) (PRINT 'ONE) )
   ( (EQ VAL 2) (PRINT 'TWO) )
   (T (PRINT 'NOT 'ONE 'OR 'TWO) )
```

COND is followed by a series of lists. The first element of each list is a condition; if this condition evaluates to a non-NIL value it is taken as being true or (T), and the remaining elements of the list are evaluated. For example, (EQ VAL 1) will have the value T if VAL is 1, and NIL otherwise. If none of the conditions are true COND returns NIL; normally, however, the last condition is T, as in the above example, so it will always be true.

DEFINING FUNCTIONS

Finally, the most important LISP function is DEF because it allows you to define new functions in LISP. As an example of defining a new function, let us see how a verbal description can be translated into a LISP function. The example used should be well known to everyone who has studied electronics: the calculation of the power dissipated in a resistor. This is given (in watts) by the equation: $P = I \uparrow 2 * R$, where I is the current in Amps, and R is the resistance. The function will be given the name POWER; after the name comes a list of the parameters that will be supplied to the function (in this case, I and R), followed by the actual definition of the function:

```
(DEFUN POWER (I R)
   (TIMES (TIMES I I) R) )
```

Trying it out for a 3 ohm resistor carrying 2 amps:

Evaluate: (POWER 2 3)

Value is: 12

WHY LISP

What are the advantages of LISP over BASIC? Two advantages will be illustrated in this article. The first is that LISP's list structures provide a very convenient way of representing certain types of data. For example, the resistor network shown in Fig. 1 can be represented by the following list where (PAR X Y) denotes that X and Y are in parallel, and (SER X Y) denotes that X and Y are in series:

(PAR (SER (PAR 1 (SER 2 3)) 4) 5)

We can write LISP functions to operate on this list; for example, to find the total resistance of the network.

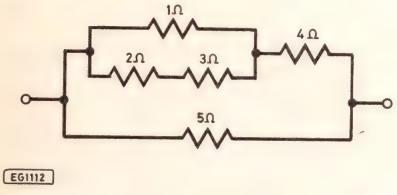


Fig. 1. Resistor network used by the LISP program described in the text.

A second advantage of LISP over BASIC is its extensibility; the programmer can add new facilities to the language itself to increase its power. For example, it might be useful to be able to define new types of data, such as complex numbers, vectors, and physical quantities, to cope with some particular application. Most languages, BASIC included, would require the programmer to set up a sub-language to handle the new datatypes. LISP, however, has the very attractive feature that the programmer can extend the definitions of the built-in functions to cope with new datatypes. This is illustrated for the following simple example which adds rational arithmetic to LISP.

RATIONAL-ARITHMETIC PACKAGE

Most implementations of LISP, at least on microcomputers, only include integer arithmetic. The rational-arithmetic package provides a way of expressing numbers which are not exact integers by extending LISP's integer arithmetic to include a new datatype, a rational number or ratio of two integers. In LISP this is represented as a list of two integers: for example, (12 23) represents the rational number: 12/23. The package can then be used to perform calculations on integers and rational numbers. Note that, unlike floating-point calculations, all calculations involving rationals using this package are exact.

To illustrate the package in use, we calculate 3+4/5:

Evaluate: (PLUS 3 '(4 5))

Value is: (19 5)

Thus the answer is 19/5.

The first step in writing the package is to provide a way of converting integers into rational form; thus the integer 6 should be converted into the rational number 6/1. We therefore define a function RAT that takes either a rational or an integer and always returns a rational; see Fig. 2.

```
(DEFUN RAT (A)
  (COND ( (NUMBERP A) (LIST A 1) ) (T A) ) )
```

Fig. 2. RAT converts an integer to a list representing a rational number.

```
(DEFUN NORM (A B (AA) (BB) )
  (SETQ AA A)
  (SETQ BB B)
  (LOOP
    (UNTIL
      (EQ
        (SETQ A (REMAINDER B (SETQ B A) ) )
        0)
      (COND
        ( (EQ BB B) (QUOTIENT£ AA B) )
        (T (LIST
          (QUOTIENT£ AA B)
          (QUOTIENT£ BB B) ) ) ) ) ) )
```

Fig. 3. NORM returns a list representing A/B as a rational in lowest terms.

It uses the built-in function LIST which makes a list out of its arguments. Thus:

Evaluate: (RAT 6)

Value is: (6 1)

Next we redefine LISP's built-in arithmetic functions with new names, so that we can refer to them in the definitions of the functions that are to replace them:

```
(SETQ PLUS£ PLUS)
(SETQ MINUS£ MINUS)
(SETQ DIFFERENCE£ DIFFERENCE)
(SETQ TIMES£ TIMES)
(SETQ QUOTIENT£ QUOTIENT)
```

The two rational numbers 6/4 and 3/2 both represent the same number; to avoid this ambiguity we keep all rational numbers in lowest terms by cancelling out any common factor between numerator and denominator. The function NORM shown in Fig. 3 takes two integer parameters A and B, and returns a list (A B) representing the rational number A/B with any common factor between A and B cancelled out. It uses Euclid's method to find the Greatest Common Divisor between A and B, and returns an integer if possible; otherwise it returns a list of two integers.

Finally, we redefine the arithmetic functions to behave as normal on integers, and to deal correctly with rationals. Here only the definitions for PLUS and QUOTIENT are given; the other functions are left as an exercise!

For PLUS, shown in Fig. 4, we use the identity:

$$a/b + c/d = (a.d + b.c)/b.d$$

Each argument is first converted to a rational number, and the final result is normalised before being returned.

QUOTIENT, shown in Fig. 5, is simpler than PLUS since it must always perform the calculation in rationals, even if the arguments are both integers.

```
(DEFUN PLUS (A B)
  (COND
    ( (AND (NUMBERP A) (NUMBERP B) )
      (PLUS£ A B) )
    (T (SETQ A (RAT A) )
      (SETQ B (RAT B) )
      (NORM
        (PLUS£
          (TIMES£ (CAR A) (CADR B) )
          (TIMES£ (CAR B) (CADR A) ) )
        (TIMES£ (CADR A) (CADR B) ) ) ) ) )
```

Fig. 4. New definition for PLUS works with rationals as well as integers.

```
(DEFUN QUOTIENT (A B)
  (SETQ A (RAT A) )
  (SETQ B (RAT B) )
  (NORM
    (TIMES£ (CAR A) (CADR B) )
    (TIMES£ (CADR A) (CAR B) ) ) )
```

Fig. 5. QUOTIENT works with rationals.

RESISTORS NETWORK

Finally, as an example of how the rational versions of PLUS and QUOTIENT can be used, consider the practical problem of calculating the resistance of the resistor network shown in Fig. 1, represented by the list:

(PAR (SER (PAR 1 (SER 2 3)) 4) 5)

From the laws governing resistors in series and parallel, namely:

s = a + b for resistors a and b in series, and 1/p = 1/a + 1/b for resistors a and b in parallel, we obtain:

```
(DEFUN SER (A B) PLUS A B) )
(DEFUN PAR (A B)
(QUOTIENT 1 (PLUS (QUOTIENT 1A)
(QUOTIENT 1 B) ) ) )
```

Finally, to calculate the resistance of the above network:

Evaluate: (PAR (SER (PAR 1 (SER 2 3)) 4) 5)

Value is: (145 59)

Thus the resistance is 145/59 ohms, (2·46Ω).

Mains Watchdog

Chris Lare

EVEN though most homes rely heavily on electrical power, a mains supply failure for a short period of time is generally little more than an inconvenience provided that it is noticed and any necessary action taken. During the night, however, it is unlikely that such a break will be observed with the result that all electro-mechanical clocks will stop for the duration of the break, and many digital clocks will simply reset. The result of oversleeping the following morning and eventually rising to find that the central heating has also stopped leaves little to the imagination.

More seriously, there are those who rely on mains electrical power for medical reasons and for whom the supply failure can be a worrying experience even though most medical equipment is fitted with battery back-up. It will always be a comfort to such people to have company during this time and it seems desirable to have a unit which will warn others of a mains failure.

The design presented here is for a small and cheap mains powered circuit which will light an l.e.d. and sound a tone if the mains fails. The circuit will detect quite short breaks (60ms) and thus should be more sensitive to mains failures than other items. It is intended that the completed unit be left switched on at all times and be used as a 'wake up' alarm in event of supply failure.

THE CIRCUIT

It was decided from the outset that the complete unit should be small and cheap to make. It is obvious that some form of battery supply to power the circuit, once the mains has failed, is needed and it was decided that a small nickel cadmium re-chargeable battery would be ideal. The cell is trickle charged during the time the mains is on by means of a small transformer mounted directly onto the circuit board.

The circuit is centred around a dual CMOS version of the well known 555 timer. One of the timers is used as a conventional astable oscillator to produce a 1kHz tone, the other as an edge triggered latch to detect and remember the supply failing. It is worth examining the action of the 555 used as a latch because it often provides a simpler and more compact solution than conventional logic designs.

In normal astable operation (Fig. 1) the capacitor charges up until the 'threshold' voltage is reached. At this time the output changes state and the discharge output pulls low, discharging the capacitor. This state continues until the 'trigger' voltage is reached when the output changes state again, the discharge output starts to float and the capacitor recharges.

It is obvious from this that the trigger is operated from a falling voltage and the threshold from a rising voltage. Both these inputs have the advantage that they are specifically designed to cope with slow edges, which would undoubtably require a Schmitt trigger interface to conventional logic latches. To use the 555 as a latch is a simple matter of omitting the timing capacitor and associated resistors. Fig. 2 shows the schematic and truth table that results from this. It is important to note two main points about the trigger and threshold inputs. Firstly, they should not be connected directly to the active supply rail which can cause lock-up in some manufacturers' parts which are not fitted with an internal bias generator and so a series resistor of some 220 ohms should always be inserted in series with the inputs, or the input should be a.c. coupled with a capacitor. The second point to note is that these inputs are level sensitive and not edge triggered, and should only be pulsed

AN AUDIO/VISUAL MAINS FAILURE WARNING SYSTEM

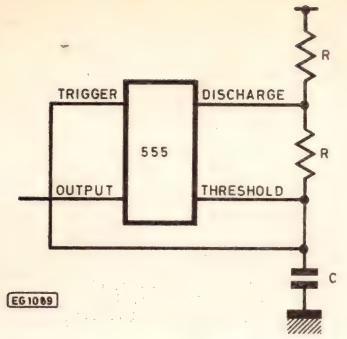


Fig. 1. Astable operation

to activate them since unstable conditions occur if they are both active at once.

In this application it is required to detect a falling edge and so the threshold input is connected to 0 volts. This is acceptable since 0 volts is not the 'active' supply rail for the threshold input. Obviously once the 555 is triggered by a falling edge on the trigger input it will remain so until manually reset, in this case by the reset button connected to the 555 reset line.

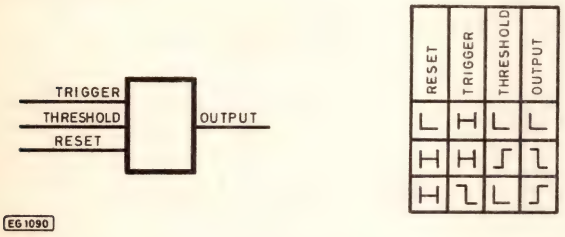


Fig. 2. Schematic and truth table for the latch including reset

A 3VA transformer was used to power the circuit (Fig. 3.). In view of the low standby power it would have been possible to derive the supply directly from the mains via dropping resistors but this was not done for reasons of safety. The transformer is connected to the mains via a 50mA fuse which will blow if the circuit fails in any way. This must not be omitted since it is intended that the final unit be left plugged in for long periods of time without any checks being made on it.

The output of the transformer is rectified by D1 and D2. This rectified power is used to trickle charge the 9 volt ni-cad battery via R1 (to limit the current) and D3 (to prevent the battery from interfering with the operation of the actual fail detection circuit). It should be noted that the regulating effect of the battery avoids the need for a smoothing capacitor.

The 15 volt Zener diode, D4, plays no part in the normal operation of the circuit and serves to limit the supply voltage to the i.c. should the battery ever become disconnected.

The actual fail detection circuit uses half a CMOS 556 as a latch with the threshold input grounded as previously described. When the mains voltage is present C2 will charge up to about 9 volts by virtue of R2 and clamp diode D5. This means that C3 is nearly discharged since R4 will hold pin 6 of the 7556 at about 9 volts as well. It is necessary to clamp the voltage on C2 to be about the same as the battery voltage or C2 would tend to discharge into the battery through R2 and the normal trickle charge path which would keep triggering the unit. When the mains input ceases C2 will discharge through R3 which in turn requires that C3 charges through R4, temporarily pulling the 7556 trigger input low as it does so.

The latch action of the timer is reset by S1, which simply grounds the reset input. Capacitor C4 is included to provide a battery power-up reset and prevent spurious noise causing erratic resets.

The output of the timer-latch is used to turn on an l.e.d. by means of a transistor buffer, required because the CMOS version of the timer cannot source sufficient current for this purpose. The output also enables a conventional astable oscillator, which, after suitable transistor buffering, is used to drive a small speaker. The volume level was limited in the prototype by a 47 ohm series resistor but this may be altered if required. The diode D8 acts as a clamp to prevent back e.m.f. from the speaker upsetting the operation of the astable circuit.

CONSTRUCTION

A small plastic box (120×40×65mm) was used to house the prototype, and the printed circuit board is designed to fit into this size of box. There is not much room in the box and it is suggested that the parts are roughly fitted and then any necessary holes drilled so that they do not foul the circuit board or the speaker. As a guide the prototype circuit board was mounted upside down in the box, the switch, l.e.d. and speaker fitting alongside the transformer below D1 and D2. The mains cable was fed through a hole in one end of the box. A 20mm hole was drilled in the bottom of the box 43mm from one end and covered with speaker cloth on the inside. The speaker was then glued in place above this hole so as to leave room for the battery plate (Fig. 4). The p.c.b. design for the circuit is shown in Fig. 5 with the component layout shown in Fig. 6.

A certain amount of care should be used when assembling the p.c.b. since parts of it carry mains voltages. Also note that if the board is to be manufactured using an etch resist pen at least 3mm should be left between those tracks carrying the mains supply and any others.

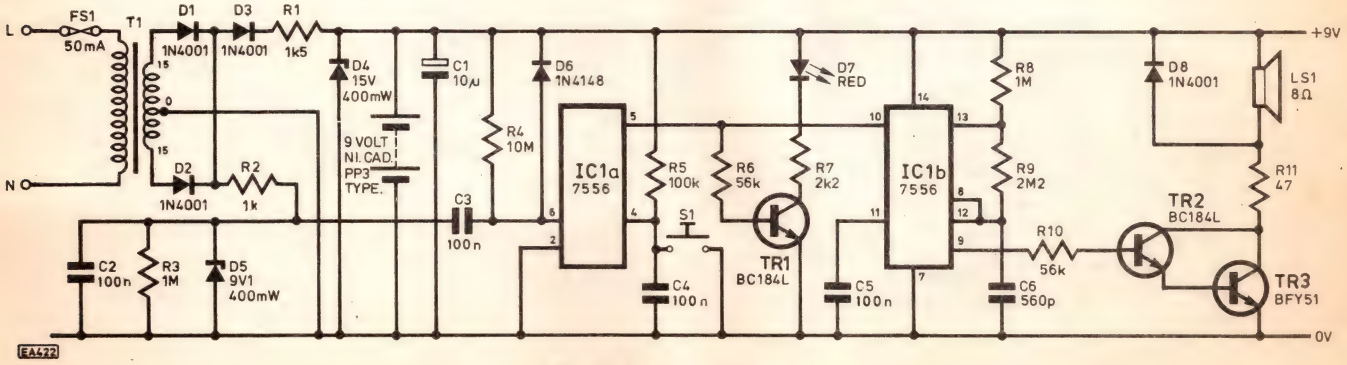


Fig. 3. Circuit diagram

COMPONENTS . . .

Resistors

R1	1k5
R2	1k
R3, R8	1M (2 off)
R4	10M
R5	100k
R6, R10	56k (2 off)
R7	2k2
R9	2M2
R11	47

Capacitors

C1	10µ 25 volt tant
C2, C3, C4, C5	100n C280 type polyester (4 off)
C6	560p polystyrene

Semiconductors

D1, D2, D3, D8	1N4001 (4 off)
D4	15V Zener 400mW
D5	9V1 Zener 400mW
D6	1N4148
D7	Red 0·2" l.e.d.
TR1, TR2	BC184L (2 off)
TR3	BFY51
IC1	ICM7556

Miscellaneous

50mA fuse and two p.c.b. fuse clips
35 ohm speaker (or 80 ohm) to fit box approx. 50mm diameter
Printed circuit board
Terminal pins
Push button switch
PP3 nickel cadmium battery
PP3 battery clip
Aluminium sheet to make battery plate
Plastic box 120 x 40 x 65mm with ribbed inner walls
Main 2 core cable and plug
Grommet and cable tie
Connecting wire

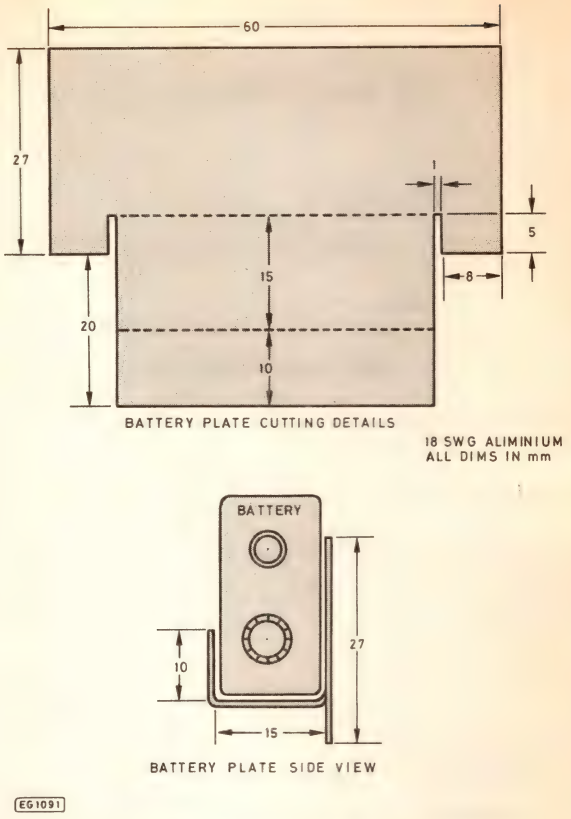


Fig. 4. Battery holder details

The prototype board was held in place in the box by the lid. Two plastic combs usually used to clip boards in were glued to the sides of the box to be flush with the top of the slots in the box wall. The complete circuit boards balanced on these and was clamped into place by the lid.

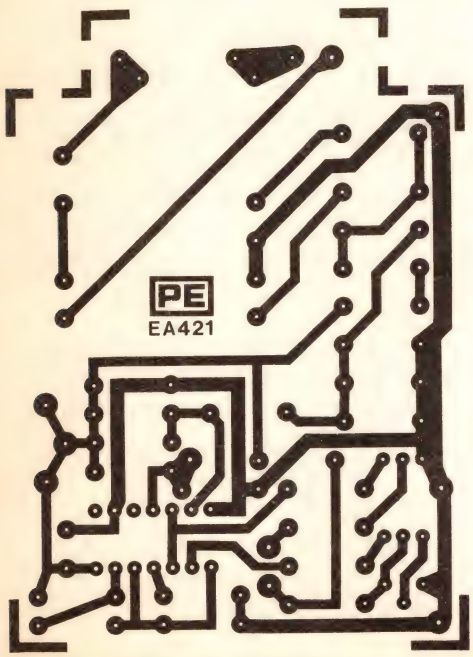


Fig. 5. P.c.b. design

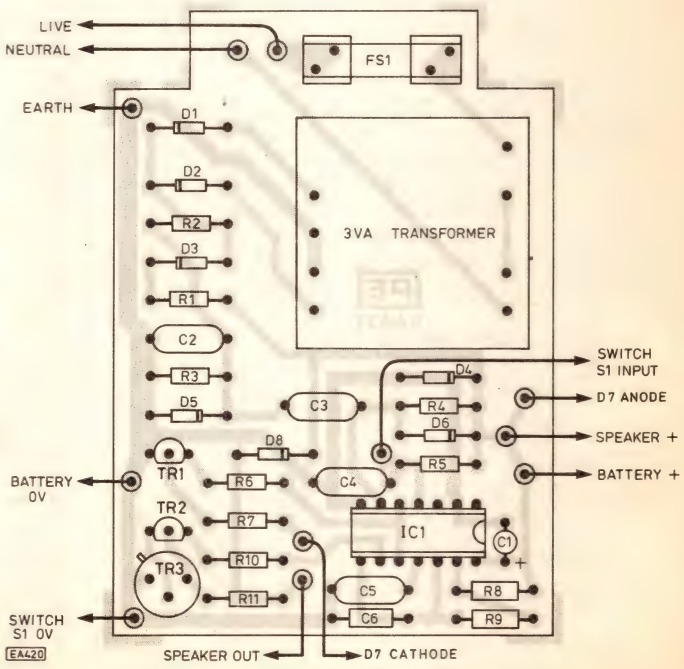
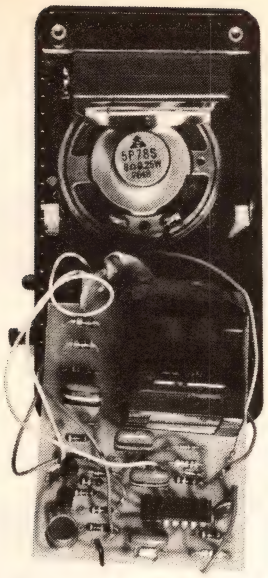


Fig. 6. Component layout



Internal view of the unit

A cable tie should be fixed around the mains cable on the inside of the box to prevent it being pulled out and a grommet must be used to stop the wire rubbing on a rough edge.

A plastic box should be used but if a metal box is required it is essential that it is earthed very well. In any case the circuit board itself should be earthed as indicated.

TESTING

Ensure that the nickel cadmium battery is disconnected before testing commences. All live parts of the circuit board must be well covered in insulating tape before the unit is plugged in. The usual precautions for handling mains powered systems must be observed.

Connect a multimeter across the battery clips and switch on. The voltage should be slightly less than 15 volts. Switch off and repeat with the meter connected across D5 when a reading of 9 volts should be seen. If the tone sounds during this time and sounds very rough do not worry since with the battery missing the circuit supply is largely unsmoothed and 50Hz hum will be superimposed on the tone. Connect in the battery and press the reset if the tone sounds.

Switch the unit on and off and the tone should now sound cleanly and the l.e.d. should light. It may happen that the tone will sound briefly and fade out; this is due to the battery being flat and so the unit should be left on for some 24 hours in order to charge the battery up.

If problems are experienced and the l.e.d. does not come on when the power is removed unplug the unit and try connecting C2 to the +ve battery terminal and then removing it to simulate mains failure. It should be possible to see the voltage on pin 6 of the i.c. kick down but remember that the meter will alter the timing relationships.

There is little to say about the unit in use. The prototype was fitted behind a bedside table and simply left alone. Do remember to reset it if the power is turned off for any reason since it will run until the battery is dead. ★

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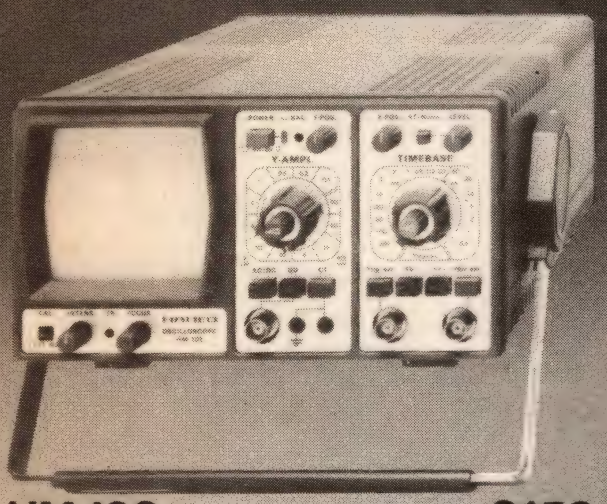

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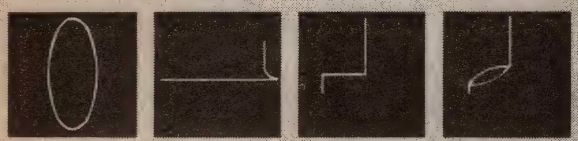

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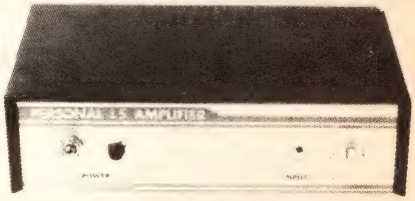
Amplifier for your personal stereo cassette player — as featured in January issue of Everyday Electronics. Turn your personal stereo into a mains powered home unit.



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Personal Stereo Amplifier

R.A.PENFOLD

PERSONAL stereo cassette and radio/cassette units provide a surprisingly high output quality despite their diminutive size and the fact that they are not fitted with Dolby B decoders (a fixed amount of treble cut normally being used when playing back cassettes). Perhaps an obvious add on for these units is a small amplifier plus a pair of compact loudspeakers. This would enable several people to listen to the unit simultaneously, would give better stereo imaging than using headphones, but would retain a degree of portability and the personal stereo unit could be used normally when maximum portability was required.

Amplifiers of this type do not appear to be available ready made, but a simple home constructor design for such an amplifier forms the subject of this article. The unit provides an output power of up to about 6 watts r.m.s. per channel with a total harmonic distortion level of only about 0·1% (typical) at most power levels. This is sufficient to give good volume from a pair of small, inexpensive loudspeakers, and many loudspeakers of this type are not able to handle higher power levels. The signal to noise ratio is better than 70dB and the noise level is negligible in comparison to that produced by the signal source. The amplifier has proper bass and treble tone controls which give the user far better control of the tone than the simple high/low tone switches.

While results are obviously not in the super-fi class, when used with a personal stereo unit and pair of compact loudspeakers of reasonable quality a very versatile portable hi-fi system having a worthwhile level of performance is produced.

THE CIRCUIT

The circuit diagram of the tone, volume, and balance controls is shown in Fig. 1, and in Fig. 2 the power amplifier.

Taking the controls first, this is a straight forward passive circuit of conventional design. The bass control gives about 12dB of boost and cut at 100Hz and the treble control gives a similar degree of boost and cut at 10kHz.

It is not strictly necessary for the unit to have a volume control since all personal stereo units have a volume control which would still function with the amplifier in use. Most personal stereo units also have some means of permitting channel balancing (usually by simply having a separate volume control for each channel). Volume and balance controls were included in the unit merely because it was felt that this would be more convenient in use, and experience with the prototype supports this belief. However, the output of the tone controls can obviously be coupled straight through to the power amplifiers if preferred, with VR3, VR4–104, R5, R6, R105, and R106 all being omitted, if the volume and balance controls are considered to be superfluous.

There is a loss of about 20dB or so through the tone and balance control circuits, but this is not important since an input level of about 1 volt r.m.s. or more will be provided by the personal stereo unit. This gives an output level of about 100mV r.m.s. from the control circuits, which is sufficient to drive a small power amplifier.

The power amplifiers each use a TDA2006 integrated circuit which is a modern device capable of excellent performance. This device only had five leadout wires; the supply terminals, the output, plus inverting and non-inverting inputs. This device has no internal bias circuits, and it is used in very much the same way as an ordinary compensated operational amplifier such as the 741C, but it has a Class B output stage which is capable of delivering a maximim output current of 3 amps and can produce an output power of several watts into a load impedance of a few ohms.

In this circuit the TDA1006s are used in the inverting amplifier mode with R7 (R107) and R8 (R108) setting the input impedance and closed loop voltage gain of the amplifiers. R9 and R10 are used to bias the non-inverting inputs of both amplifiers to about half the supply voltage, and C8 prevents hum or other noise on the supply lines from being coupled into the amplifiers via the bias circuit. D1, D2, D101 and D102 are protection diodes, and C5 plus C105 are supply decoupling capacitors which are mounted physically close to IC1 and IC101 respectively to prevent instability.

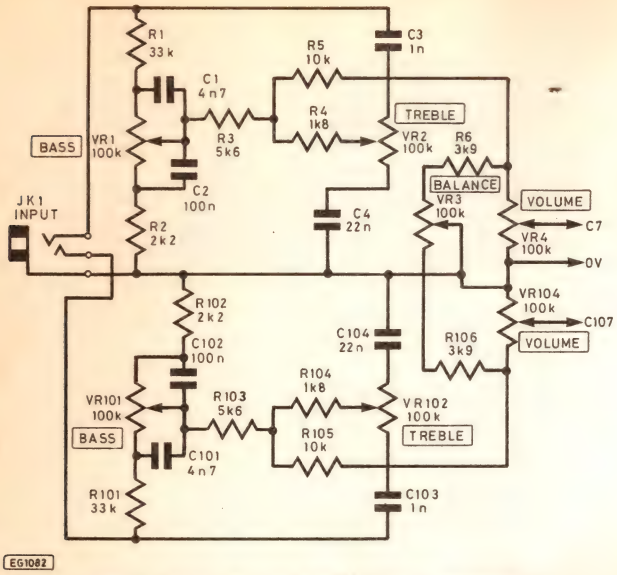


Fig. 1. Tone, volume and balance controls

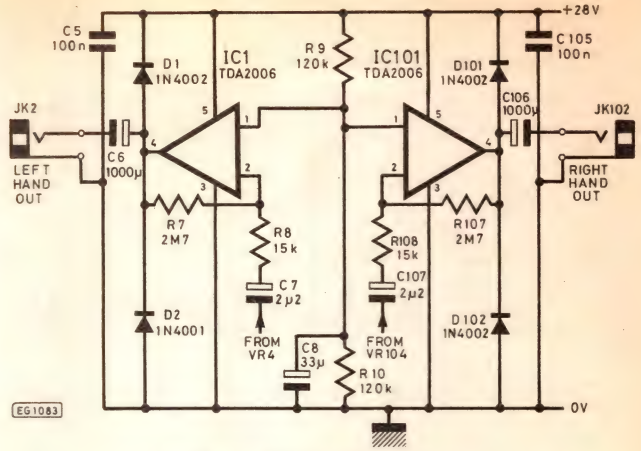


Fig. 2. Power amplifier

MAINS POWER SUPPLY

Although battery operation of the amplifier would have the advantage of making the unit self contained, this is not really feasible since a supply potential of about 22 volts is required, and at high output powers the current consumption of the circuit exceeds 800 milliamps. The simple mains power supply circuit of Fig. 3 is therefore used to power the amplifier.

This is a straightforward non-regulated design using a bridge rectifier and smoothing capacitor C9. There is a significant amount of ripple on the output of the supply, but the TDA2006 devices used in the power amplifiers have 50dB of supply ripple rejection, and the filter used in the bias circuit of the power amplifiers also gives good immunity to hum on the supply lines. This results in no discernible mains hum from the loudspeakers despite the simplicity of the power supply circuit.

T1 is a toroidal transformer which has two 9 volt secondaries that are used in series in this circuit. This gives an unloaded supply voltage of just over 28 volts, but this falls slightly under quiescent loading, and reduces to about 22 volts with both channels fully driven.

Fuse FS1 should be an antisurge type rather than the more common quick-blow variety since the secondary windings of T1 provide a series of pulses of current to C9, not a reasonably constant current flow. There is also a large current flow at switch-on as C9 initially charges up, and there would be a danger of a quick-blow fuse "blowing" unnecessarily

CONSTRUCTION

A printed circuit board accommodates all the components apart form the mains transformer, on/off switch S1, and the sockets. Details of the printed circuit board and wiring of the unit are shown in Fig. 4.

Construction of the printed circuit board is easiest if the small components are soldered in place first, followed by the four controls, C6, C106, and finally C9. It would of course be possible to use ordinary potentiometers in the unit, but they would have to be mounted off-board and hard-wired to the component panel. Construction is far simpler using the correct printed circuit mounting potentiometers, and their use is strongly recommended.

Use pins in the printed circuit board at the points where it will be connected to T1 and the three sockets. Before soldering the integrated circuits into place carefully form the leadout wires of the devices and position them so that their mounting holes are aligned with the mounting holes in the board. It will be impossible to manoeuvre the integrated circuits into the correct position without risk of damage once they have been soldered into place. Make sure that the potentiometers are pushed right down into place before soldering them into position.

The recommended case is of aluminium and steel construction with approximate outside dimensions of 300 by 150 by 60mm, but any case having similar or larger dimensions should, with a little ingenuity, be just as suitable. Assuming the specified case is used the front panel is drilled as shown in Fig. 5, and this layout should be accurately copied or it will probably be impossible to fit all the components into the case.

When the four potentiometers are mounted on the front panel they provide the front mounting for the printed circuit board. An 18 s.w.g. aluminium mounting bracket is used to support the rear of the board and also provides a certain amount of heatsinking for the two integrated circuits. Details of the mounting bracket are provided in Fig. 6. One part of the bracket is placed between the printed circuit board and the heat tabs of the two integrated circuits, and then 6BA or M3 screws about 6mm long are used to bolt the bracket, board, and integrated circuits together. The lower part of the bracket is fixed to the base panel of the case, again using 6BA or M3 bolts about 6mm long. It is essential for the mounting holes in the base panel of the case to be accurately positioned, and it is probably best to fit the front panel, board, and bracket assembly in place in the case, check that the front panel is in the correct vertical position, and then use the bracket as a template to help mark the positions of the mounting holes on the base panel. A lack of accuracy here could make it impossible to fit the lid.

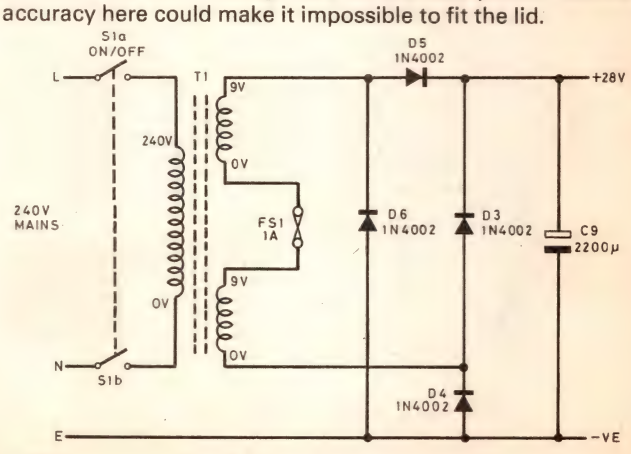
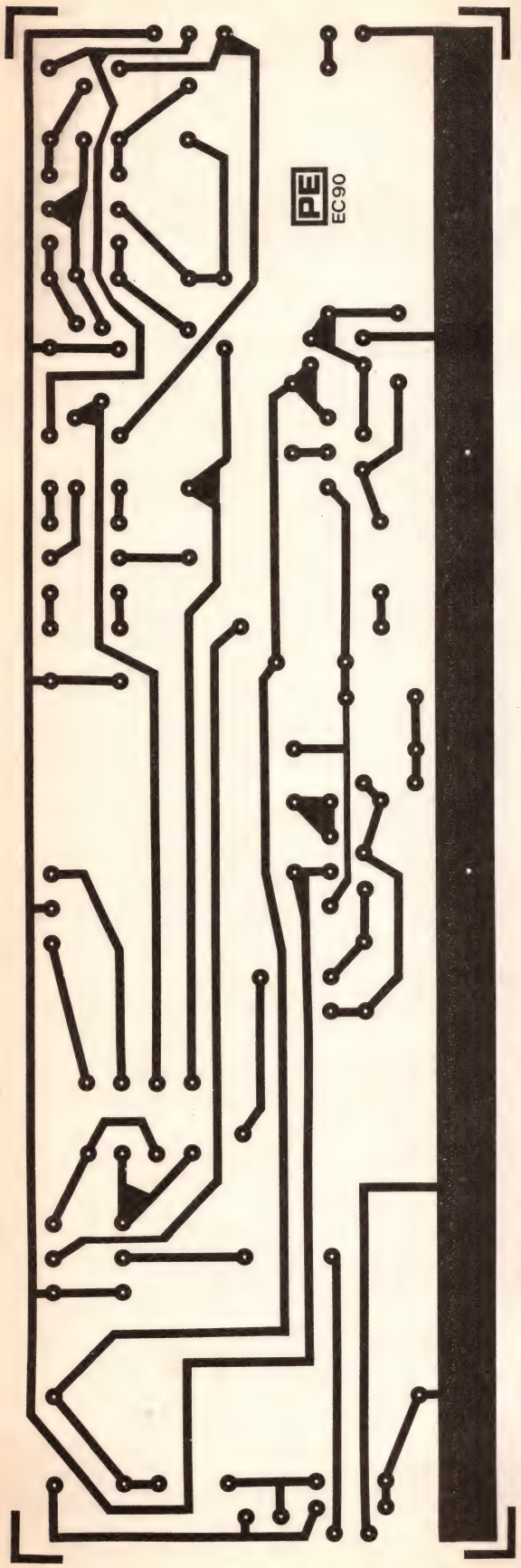
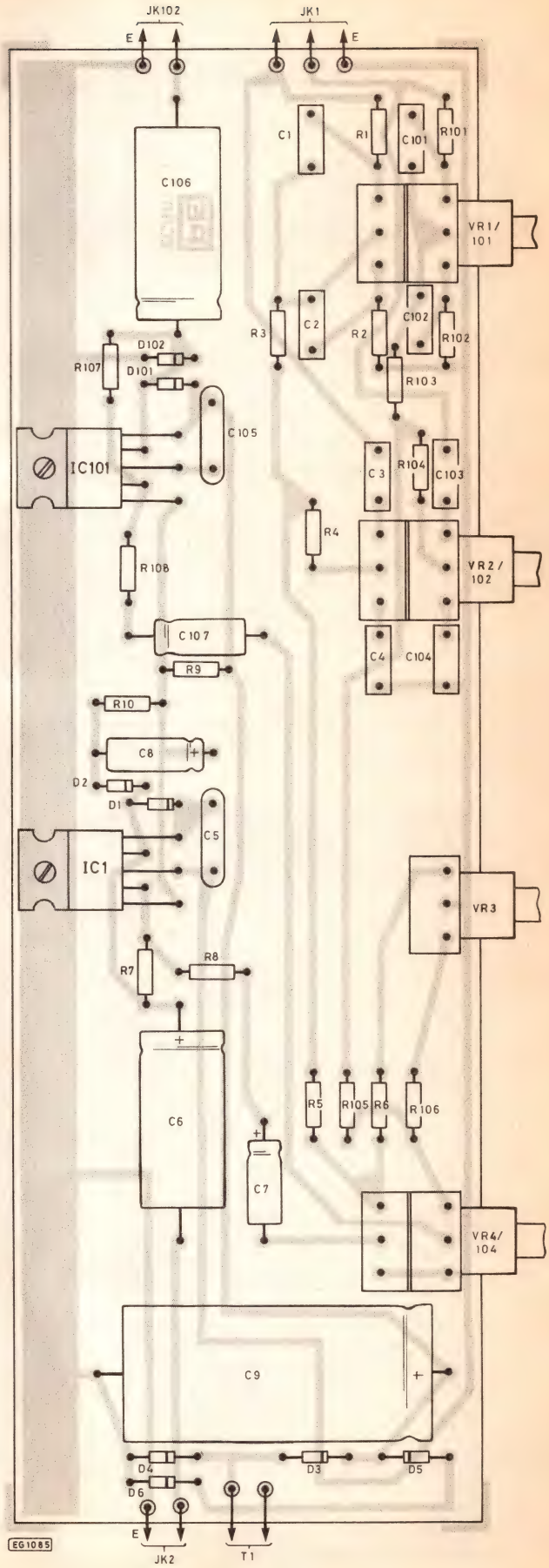


Fig. 3. Mains power supply

Fig. 4. P.c.b. and component layout





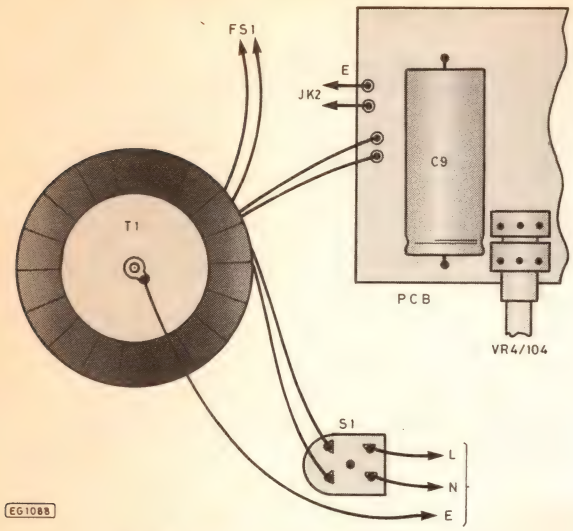
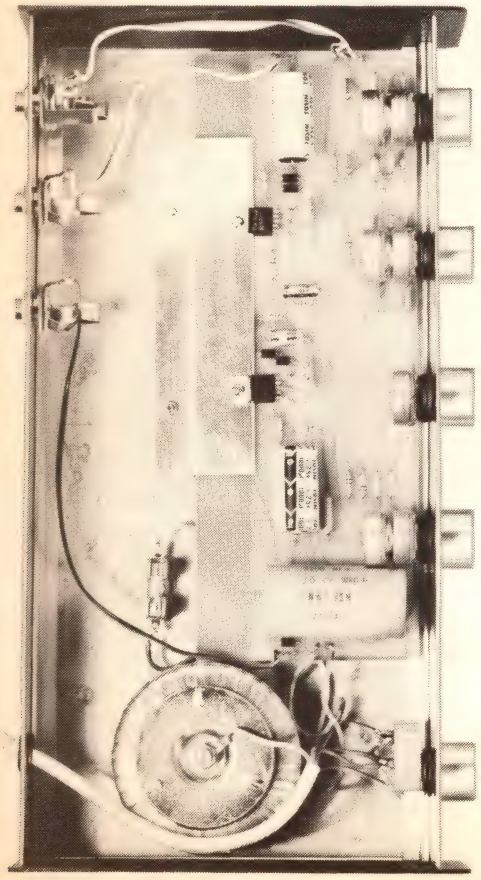


Fig. 5. Transformer connections

Mains transformer T1 is mounted on the base panel of the case to the left of the component board, and the toroidal component specified in the components list is supplied complete with a mounting kit. A single 6mm diameter mounting hole is required. A large solder tag fitted on T1's mounting bolt provides a chassis connection for the mains earth lead. The chassis mounting fuseholder for FS1 is mounted at any convenient place on the base of the case close to T1. An entrance hole for the mains lead is drilled in the rear panel near to T1 and this hole must be fitted with a grommet to protect the cable. The input and output sockets are mounted at the other end of the rear panel.



COMPONENTS . . .

Resistors

R1, 101	33k (2 off)
R2, 102	2k2 (2 off)
R3, 103	5k6 (2 off)
R4, 104	1k8 (2 off)
R5, 105	10k (2 off)
R6, 106	3k9 (2 off)
R7, 107	2M7 (2 off)
R8, 108	15k (2 off)
R9, 10	120k (2 off)

All 1/4 watt 5% carbon

Potentiometers

VR1–101, VR2–102	100k lin. dual gang printed circuit mounting (2 off)
VR3	100k lin. printed circuit mounting
VR4–104	100k log. dual gang printed circuit mounting

Capacitors

C1, 101	4n7 carbonate (2 off)
C2, 102	100n carbonate (2 off)
C3, 103	1n carbonate (2 off)
C4, 104	22n carbonate (2 off)
C5, 105	100n polyester (2 off)
C6, 106	1000u 25V axial electrolytic (2 off)
C7, 107	2u2 63V axial electrolytic (2 off)
C8	33u 16V axial electrolytic
C9	2200u 40V axial electrolytic

Semiconductors

IC1, 101	TDA2006 (2 off)
D1 to 6, 101, 102	1N4002 (8 off)

Switch

S1	Double pole rotary on/off mains type

Miscellaneous

JK1	Standard 6·35mm stereo jack socket
JK2, 102	Standard 6·35mm mono jack socket (2 off)
T1	30VA toroidal mains transformer with twin 9 volt secondary windings (ILP Transformers Ltd)
FS1	1A 20mm antisurge fuse
	Chassis mounting holder for FS1
	Printed circuit board
	Five control knobs
	Case type DX4 or similar (300 x 150 x 60mm)
	Cabinet feet
	Connecting lead with standard stereo and 3·5mm stereo jack plugs (Maplin)
	Veropins
	18 s.w.g. aluminium for heatsink
	Mains lead, mains plug, connecting wire, etc.
	Pair of compact 8 ohm impedance loudspeaker enclosures (e.g. Maplin 5W system)

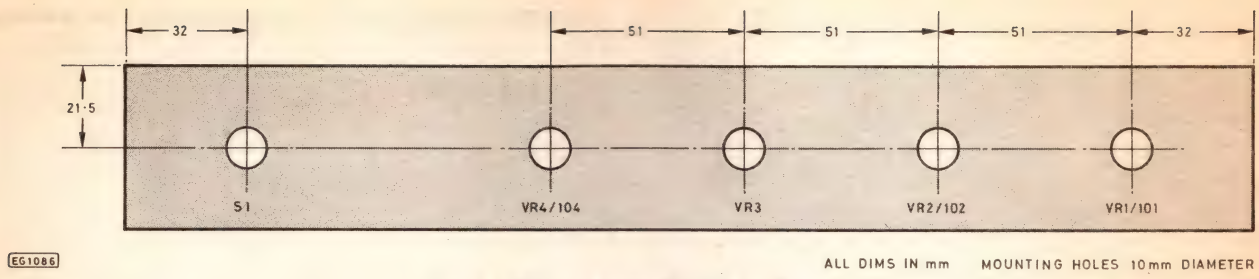


Fig. 6. Drilling details of the front panel

Once all the components have been fitted in place the final wiring can be completed. Due to the fairly low sensitivity of the amplifier and the very weak magnetic field of the toroidal transformer used for T1 there is no need to use screened cable to connect the printed circuit board to JK1. If output sockets JK2 and JK102 are not insulated types be careful to connect these correctly or the output will be short circuited. The TDA2006 integrated circuit has thermal and output short circuit protection built-in incidentally, and accidental overloads on the output would probably not result in the destruction of the output devices. Of course, JK2 and JK102 can be replaced with two way DIN sockets or some other type of connector if this would be more convenient in use.

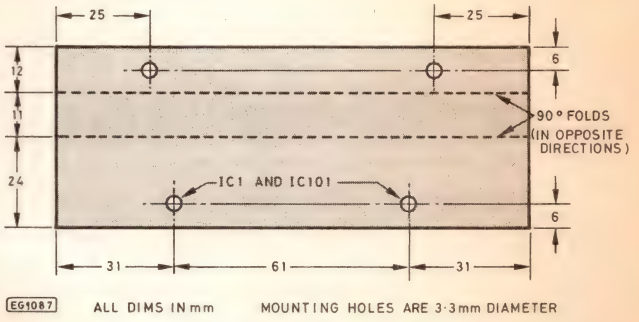


Fig. 7. Heatsink and board mounting bracket

IN USE

The output of the unit is coupled to the input socket of the amplifier using a three way lead fitted with a 3·5mm stereo jack (which connects to the personal stereo unit) and a standard 6·35mm stereo jack (which connects to the input of the amplifier). Due to the fairly low source impedance and high signal level it is not necessary to use a screened lead. Personal stereo units normally have the output socket wired so that the tip of the output jack carries the left hand channel, incidentally.

The volume controls on the personal stereo unit should be set at a position that would give a good high volume level if the unit was used with headphones, but should not be advanced so far that there is a danger of clipping occurring during periods of high volume. The tone switch should be set to the "high" position. Volume, balance, and tone are then adjusted using the controls on the amplifier.

Only 8 ohm impedance loudspeakers are recommended for use with the Personal Stereo Amplifier since higher impedance types would give a much lower maximum output power, and lower impedance speakers would almost certainly overload the power supply and cause FS1 to rupture. It is not difficult to build your own loudspeaker enclosures using modern materials, but there are a number of suitable commercially produced speakers which are suitable. In either case make sure that the speakers are rated at about 5 watts r.m.s. or more. Note that bookshelf monitor speakers are not suitable for use with this amplifier due to the low efficiency of speakers of this type, which consequently need quite a high input power in order to give high volume levels.

BAZAAR

ADM1 terminal, circuit diags/service manual wanted. Any info welcome. Will buy or pay for loan. Richard Williams, 13 Shorediche Close, Ickenham, Uxbridge UB10 8EB. Tel: Ruislip 31500.

WANTED Sinclair ZX81 or ZX80, with leads. Will pay up to £25. Oiaf Mackenzie, 22 Broomieknowe Gardens, Bonnyrigg, Midlothian EH19 2JD. Tel: (031 663) 7079.

WANTED ZX81 or Spectrum and Casio FX 702P with or without cassette interface. Erik Bjerke, Ostre Totenvei 10, N-2800 Gjovik, Norway.

UK101 8K Cegmon Wemon new BASIC 1/3 Expansion interface with sound, I/O, Printer Port, A/D, D/A £95. Steven Betteley, 32 Stoneygate Drive, Hinckley, Leicestershire. Tel: Hinckley (0455) 612592 (evenings).

MPF1-B BASIC p.s.u. manuals, in original packing. First offer over £60 secures. Ian Buckingham, 7 Railway Cottages, Thorpe, Norwich. Tel: (0603) 663474.

AMPLIFIER for sale. 15W stereo. Bi-Pak PA100 Pre-amp. Sinclair amps. Teak case. Good condition. £25 o.n.o. Mr. J. D. Parkes. Tel: Wolverhampton (0902) 756806.

HEATHKIT four band receiver AR-2000 MK II, mint condition. Needs tuning on f.m. £90 o.n.o. Write: D. Johnston Esq., 42 Shore Street, Anstruther, Fife, Scotland KY10 3AQ.

SYNTH. Korg MS20. Factory built, 2xVCO, 2xVCA, 2xVCF F-to-V. New, £470. £200/Disk Drive/Printer/w.h.y. Mr. E. Phipps, 77 Fitzpain Rd., West Parley, Wimborne, Dorset BH22 8SF. Tel: (0202) 576681.

WANTED Construction details for converting 12V car battery charger to a CB power supply. Mr. J. Whitehurst, 2 Cumberland Rd., Congleton, Cheshire CW12 4PH.

ORGAN parts, including pedal boards, 5-octave keyboards, generator, chokes, stop tabs, many others, s.a.e. for large list. K. Wolsey, 'Puffins,' Seaview Lane, Seaview, IOW PO34 5DG.

MAPLIN organ pedals, no electronics, £10. Buyer collects. Foster. Tel: Hull (0482) 851366.

P.E. HI-FI tape link, abandoned project, all components, p.c.b.s. built, Bogen heads. 7" reel deck. £45. Mr. S. G. Waddington, 3 Merrick View, Stewarton, Kilmarnock, Ayrshire KA3 5EU. Tel: Stewarton (0560) 82770.

WANTED Case suitable for the UK101 computer board (must allow raked keyboard). Mr. M. B. Hart, 9 Strand Rd., Hoylake, Wirral LA7 2DA. Tel: (051) 632 2366.

SWAP/SELL AVO 8. Wanted ZX81 or other computer. Tel: (040 926) 267. Robin Roy.

HANNIMEX cartridge colour t.v. games console with 2 joysticks, 4 cartridges. Motorbike control handle. £50. Tel: (041 332) 7695. 7 p.m. K. Y. Chang, 70 1-up Ashley St., Glasgow G3 6HW.

KEYBOARD, 5 octave, including mounted double pole gold-plated key switches. £30. Tel: 01-422 0536 (Harrow). R. Terrett, 291 Somervell Road, South Harrow, Middx. HA2 8UB.

LEAK Varislope stereo, Trough line 3 tuner, "Sandwich" speakers. Garard 301 and Decca arm/pick-up. Offers. Davies, 17 Highfield Close, Malvern, Worcs.

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LSI II memory board 32K, 18 bits, m.o.s., module No. M8045, as new. Open to offers. S. T. Whitehead, 131 Manchester Rd., Haslingden, Rossendale, Lancs BB4 6NT. Tel: Ross (0706) 216283.

ATOM 17K RAM. FP ROM. Toolbox ROM. PIA 3A p.s.u. games software books, manual. £195. Tel: (0246) 433565 (Chesterfield). C. H. Westlake, 112 Ravencar Rd., Eckington, Sheffield S31 9GN.

Patents Review

Copies of Patents can be obtained from:
the Patents Office Sales, St. Mary Cray, Orpington, Kent. Price £1·60 each.

TV WARNING

The unexciting title "Object Detecting Apparatus" for British patent application 2 090 411 from Tokyo Shibaura Denki of Japan, in fact covers a fascinating invention demonstrated by Toshiba at the London electronics trade shows in May 1981. Either by good planning or good fortune the patent claims priority dates of December 1980 and April 1981. It is of course a basic principle of British patent law (often overlooked by amateur inventors) that a patent application is invalid if it is filed after the invention has been shown off, other than under strict seal of confidence.

The Toshiba object detecting apparatus is a television set which senses the presence of a viewer and his or her distance from the screen. If a viewer comes too close and so risks getting eye strain, the set issues a warning in a synthesized voice. According to the patent the set says "You get too close to the TV set", and "stay away a little". In fact the Toshiba set, as demonstrated in Britain, spoke rather better English, "Watch from a distance for your eyes sake" it told anyone who got too close. The lengthy patent gives details of the clever circuits used to discriminate between furniture and viewers.

In Fig. 1 timing signal generator 26 is reset on the trailing edge of the output signals from oscillator 18. The output of monostable 20 controls oscillator 28, which produces an ultrasonic signal of between 40 and 60 kHz. This is radiated into the room by speaker 30.

Microphone 32 receives the wave reflected from furniture and viewers in the room and the received signal is amplified at 34, rectified at 36 and applied to sample and hold circuit 38. The sampled signal is compared at 40 with a reference signal from generator 42. Discrimination is achieved by storing the reflected signal during several periods of oscillator 18 and comparing the stored signal pattern with each subsequent received pattern. After counter 24 has clocked a given number of pulses e.g. 3, from oscillator 18 the flip-flop 52 is set. Data stored in memory 54 is then successively compared with reflected data in judging circuit 56. If the stored and received data match there is no change in the room. When they don't match the judging circuit 56 produces an output which triggers speech synthesizer 58.

The inventors claim that the invention is also usable as a security system for detecting burglars in the room. The output of judging circuit 56 then can be switched to sound an alarm.

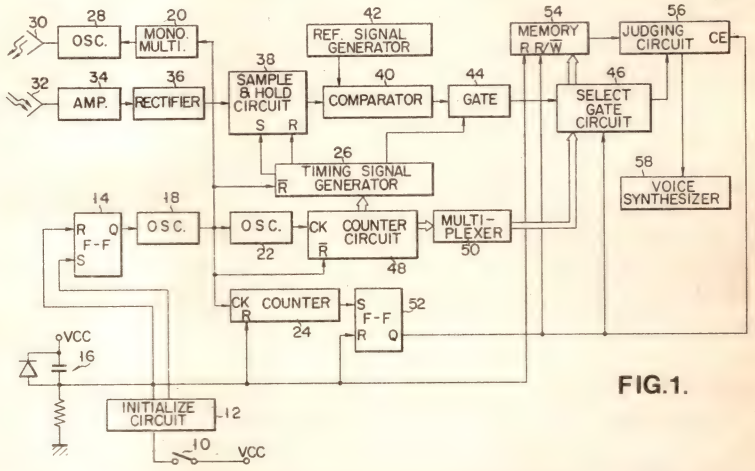

FIG.1.

AUTOMATIC CUT-OUT

PCT application 82/03520 covers a device which could be useful for anyone who has a habit of leaving their soldering iron switched on and unattended. The application, which is filed in Germany, France, Britain, Japan and Holland, by Robert Franklin of California, is for an automatic power shut off system. It can be incorporated in any appliance which uses a heater element and is thus a fire hazard and expensive waste of energy. Or it can be connected as an add-on extra.

Fig. 1 shows the basic idea. Appliance 49, such as a soldering iron, receives a.c. power on line 46, 47. Triac 45 gates power to its heater element 53 via thermostat switch 52.

Use Detector and Timer (UDT) 1 has a master oscillator 12 which drives clock counter 15. This is pre-set to establish a period during which use of the appliance must be registered by a detector 2 to prevent a power shut down. Detector 2 can work by sensing motion of the appliance 49, or a grip on its handle, and can be either a touch sensitive switch, a piezo electric motion detector, a strain gauge, or a light or magnetic sensor. When detector 2 senses use, it re-sets UDT to zero. If no use is detected before the pre-set time, of say 15 minutes, runs out, then audible alarm 55 sounds and warning light 54 glows. This tells the user that the power is soon going to be turned off if the appliance isn't used. If it is used, the detector 2 resets the UDT to zero and it then starts counting again. If it isn't used then, 15 seconds after the warning, optic coupler 43 is switched off. This removes the gate drive for triac 45 which shuts off the power to appliance 49. Power is restored by touching the use detector 2 or momentarily unplugging UDT 1.

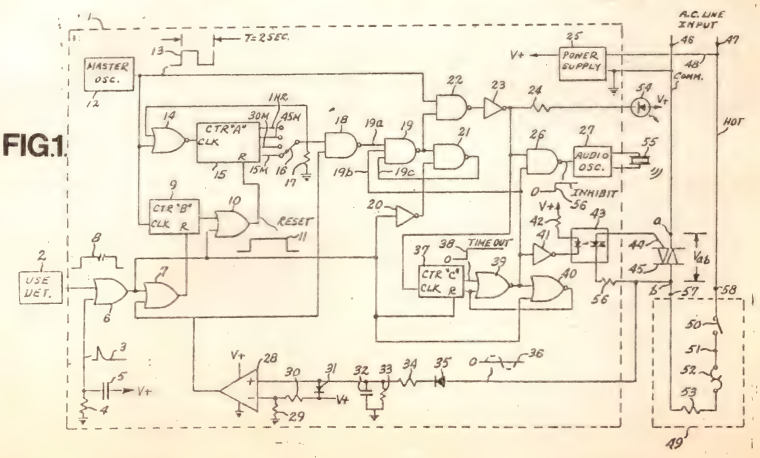

FIG.1

VIDEOTONE

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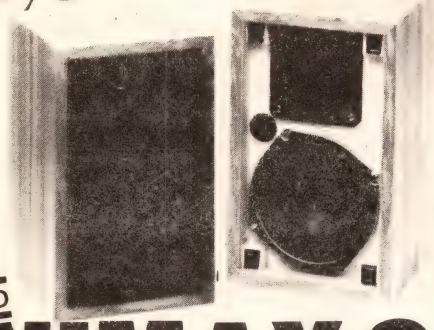

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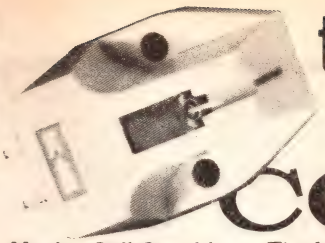

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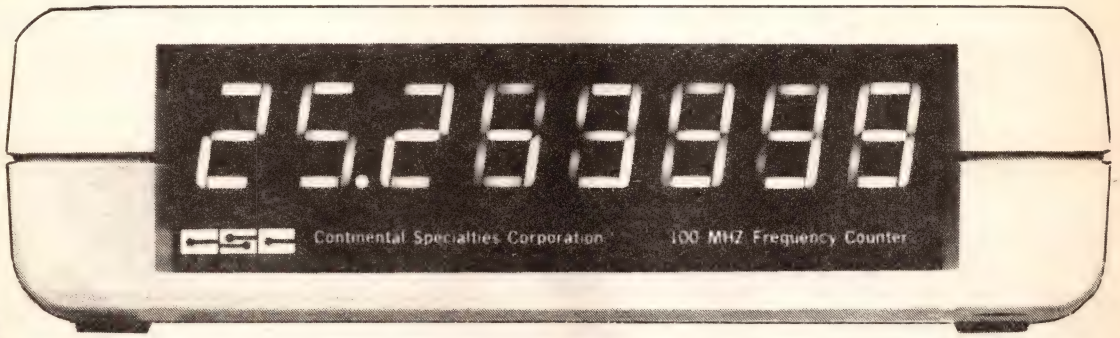

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into the REAL WORLD part 4

CONTROL CIRCUITS

Michael Tooley B.A.
David Whitfield M.A. M.Sc.

MICROPROCESSORS in control situations are concerned with the real world where the majority of situations involve the control of equipment which has not necessarily been designed with microprocessors in mind. This is particularly true of most mains-powered equipment, and in this part of the series we begin by examining some useful methods of power control. The essential theme of these techniques is to bring the power of the micro to bear in a control sense, while keeping the power source in the application safely at arms length.

A desirable aspect of any control system is that it should be able to talk to the operator. The series so far has made little mention of the topic of display driving, and this omission is covered by concluding the series with a description of some of the more commonly encountered numerical display techniques.

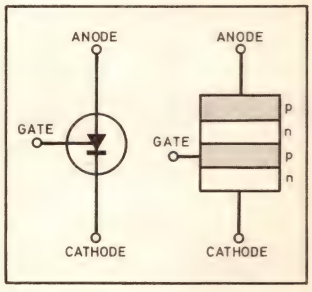
POWER CONTROL DEVICES

The traditional method of interfacing an electronic control circuit to a load which is connected to an a.c. supply has involved the use of an electromechanical relay. Such devices offer a simple, low cost, solution to the problem of maintaining adequate isolation between the control circuit and the potentially lethal voltages associated with the supply mains. Relays do in fact, offer many of the characteristics of an 'ideal' switch including very low 'on' resistance, very high 'off' resistance and a coil to contact breakdown voltage which is usually in excess of several kV. There are, however, several very serious disadvantages of the humble electromagnetic relay. These are principally associated with the transitory condition which occurs between the true 'on' and 'off' states. When current is applied to energise the coil of an electromagnetic relay, the relay contacts are relatively slow to react and, after this initial delay in response, several milliseconds of contact bounce can occur. This rapid fluctuation in the 'on' and 'off' state can cause rapid changes in load current which in turn may result in severe erosion of the relay contacts coupled with electromagnetic radiation over a wide range of frequencies.

When the energising current is removed from the relay coil, there is again some delay in the operation of the contacts and, whereas there is less likelihood of bounce on opening than closing, the air-gap between the relay contacts tends to ionise as the contacts open. Since the ionised air acts as a relatively good conductor, the arc only becomes extinguished when the line voltage approaches that required to sustain the arc. In this condition an excessive level of power can be dissipated in the space between the contacts. There is thus a safe working limit for every relay beyond which the contacts may suffer permanent damage and eventually burn-out! Readers should also note that, whereas a relay may be rated for operation at 240V a.c. its d.c. rating may be considerably less. This is by virtue of the fact that any arc produced between the contacts will become extinguished at the end of a half-cycle of the a.c. mains. With a d.c. supply of more than 50V, an arc may persist for some considerable time.

Modern semiconductor devices have fortunately provided the circuit designer with some elegant solutions to the problems of a.c. and d.c. power control. Silicon controlled rectifiers (also known as thyristors) and their derivatives have become commonplace in many power control applications, such as motor speed control and light dimming.

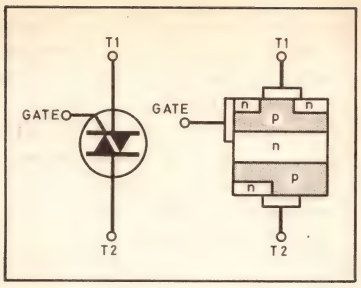
A silicon controlled rectifier (s.c.r.) is a four layer three terminal semiconductor device. Such a device will conduct a unidirectional load current whenever the rectifier has been triggered by the injection of a pulse of current into its gate. Provided that the latching value of current is exceeded, the device will remain in the 'on' conducting state until the anode current falls below a certain minimum value. This holding value is the minimum anode current that can flow through the s.c.r. and still maintain conduction. Such a condition can, of course, easily be achieved by momentarily interrupting the supply to the device. The symbol and internal arrangement of an s.c.r. is shown in Fig. 1.



EG1095

Fig. 1. Symbol and internal arrangement of a thyristor

An s.c.r. is, by virtue of its unidirectional property, ideally suited to d.c. power control applications. In a.c. circuits a single s.c.r. can only provide control over half-cycles of the supply. The triac is a development of the s.c.r. which can be used to pass or block current in either direction. The device essentially comprises two thyristor devices connected in anti-parallel but sharing a common gate electrode. The symbol and internal arrangement of such a device is shown in Fig. 2. The triac, like the s.c.r., has a minimum holding current below which conduction cannot be maintained. The device can, however, be triggered by both positive and negative gate current pulses. A complete discussion of the properties and characteristics of s.c.r. and triac devices is beyond the scope of this series and, where further information is required, readers are recommended to consult one of the currently available thyristor and s.c.r. manuals.

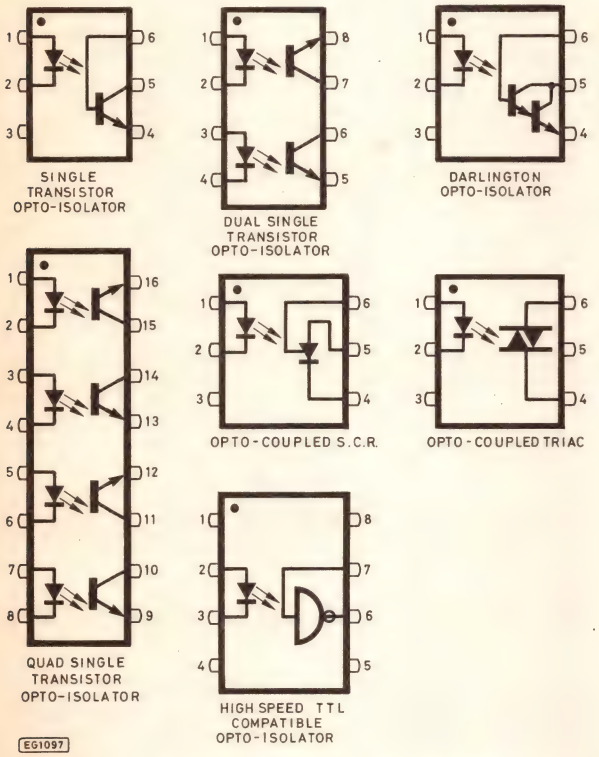


EG1096

Fig. 2. Symbol and internal arrangement of a triac

OPTO-ISOLATORS

Opto-isolators provide a means of coupling signals without the need for a direct electrical connection between devices. Signals are conveyed by means of a beam of infra-red radiation linking an emitting device to a detector housed in a common light-proof enclosure. The emitting device usually takes the form of a gallium arsenide diode whereas the detector may take one of several forms including photo-transistor and photo-Darlington arrays. Photo-coupled s.c.r. and triac devices are also available. A variety of opto-coupled devices are shown, together with their conventional pin-outs, in Fig. 3.



EG1097

Fig. 3. A range of opto-coupled devices

The maximum voltage which can safely be applied between the input (emitter) and output (detector) terminals of an opto-isolator is usually in the range 1 to 7·5kV. This is comparable with the coil to contact breakdown voltage of most electromechanical relays. The insulation resistance of an opto-coupled device is generally around 10^{11} and 10^{12} ohm. This should be more than adequate for most applications including coupling to the 240V a.c. mains supply.

The efficiency of an opto-coupled diode, transistor or Darlington is usually expressed in terms of current transfer ratio (c.t.r.). This is simply the ratio of detector (output) to emitter (input) current. A typical c.t.r. for an opto-coupled transistor is 0·5 whilst that for an opto-coupled Darlington can be as much as 800. Since c.t.r. varies widely with emitter current, values must be specified for operation under particular conditions (i.e. emitter current, temperature etc).

The infra-red emitters of most opto-isolators have a maximum continuous current rating of between 20 and 60mA. The forward voltage drop of such a device is usually around 1·2V whilst the maximum reverse voltage maybe as low as 3 to 5V. A fixed current limiting resistor is often connected in series with the emitter in order to limit the current when driven from a conventional TTL logic gate. Values of between 180 and 270 ohm will limit the emitter current to between 17 and 10mA, respectively. Whereas the emitter is common to a range of opto-coupled devices, detectors tend to vary quite considerably. Desirable characteristics include not only a high value of c.t.r., but also a fast response. Devices which may be perfectly adequate for control applications in conjunction with the supply mains may be quite unsuitable for high speed data transmission. A range of fast opto-isolators have recently become available. Typical of these is the HCPL2601, the simplified internal block diagram of which is shown in Fig. 4. The detector is coupled

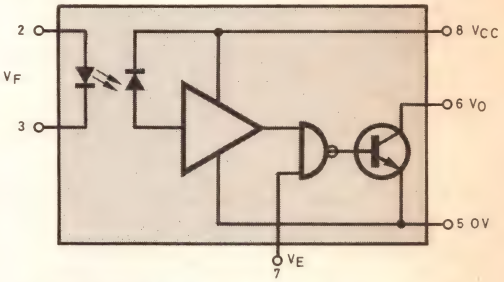


Fig. 4. Simplified internal block diagram of a high speed TTL compatible opto-isolator

INPUT V_F	ENABLE V_E	OUTPUT V_O
H	H	L
L	H	H
H	L	H
L	L	H

EG1098

Table 1. Truth table for the isolator shown in Fig. 4

to an integrated high gain amplifier which is followed by an AND gate. An enable input is provided to this gate and it, in turn, is followed by an open collector Schottky clamped transistor. An internal screen provides a common mode transient immunity of 1kV/µs. This is equivalent to rejecting a 1MHz sine wave of no less than 300V pk–pk!

PRACTICAL POWER CONTROL CIRCUITS

A practical arrangement for interfacing a microcontroller or microcomputer to a load driven from the a.c. mains supply is shown in Fig. 5. This simple circuit uses a Darlington opto-isolator coupled to a triac. When the input is held 'low', gate current flows and the triac conducts allowing current to flow through the load. Note that triggering only occurs on positive half-cycles of the supply and thus this circuit is limited to a maximum load of around 500W. Fig. 6 shows an arrangement which employs an opto-coupled thyristor in conjunction with a bridge rectifier and triac. The bridge rectifier allows triggering on both positive and negative half cycles of the supply. The series C–R network connected across the triac is known as a 'snubber' and is used to compensate for

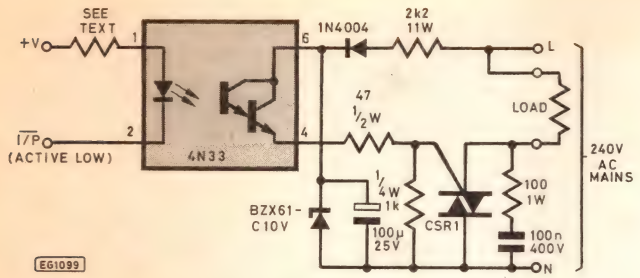


Fig. 5. A simple a.c. power control circuit using a Darlington opto-isolator

the effects of an inductive load. This network may be omitted when the load is purely resistive (such as an electric fire or light). An arrangement using an opto-coupled triac is shown in Fig. 7. Additional components have been included to cater for severely reactive loads. Where the power factor of the load is unknown, components should be fitted for a power factor of 0·9. This circuit is capable of controlling load powers in excess of 1kW.

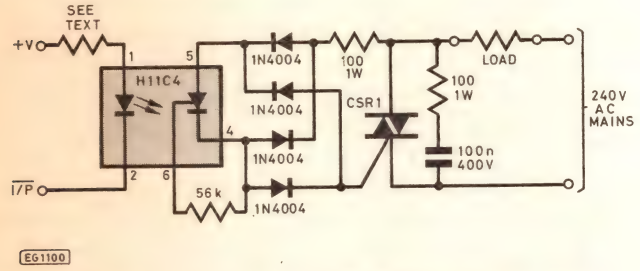


Fig. 6. An a.c. power control circuit using an opto-coupled thyristor

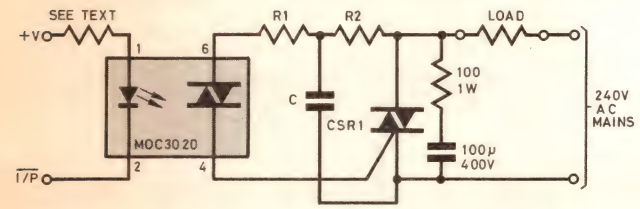


Fig. 7. Power control arrangement using an opto-coupled triac

LOAD POWER FACTOR	R1	R2	C
1	220	NIL	N.C.
0·9	180	560	100n
0·75	180	580	220n
0·5	180	680	330n

EG1101

Table 2. Component values for use with reactive loads

DISPLAY DRIVING

The control of displays is one of those areas of microprocessor system design, rather like keyboard handling, where the designer has the opportunity of making a number of hardware and software tradeoffs. The actual details of the tradeoffs which may be made, or even considered, will usually be determined by the characteristics of the particular application. In general, however, the factors to be considered will include: the amount of hardware involved, the complexity of the software required, the time available to perform the task, the memory space required, the speed of response, and any other tasks which must be performed concurrently.

Particular applications will have their own additional design constraints over and above those described above. Displays in hand-held applications, for example, will have tight space and power consumption constraints. The first step in all cases, however, will be to determine the extent to which hardware and software tradeoffs are practical, or even available; there is, after all, little point in deciding to use regular timer interrupts in a system where all of the user interrupt facilities have already been utilised.

Having defined the problem, and detailed the working limits for any solution, the designer is left with the task of producing a working design. There are few truly general guidelines which may be given, but careful consideration of flexibility, adaptability, future expansion possibilities, simplicity/modularity, and cost will usually help to narrow down the range of available choices. The discussion below covers some of the ways in which a typical seven-segment display may be controlled, and illustrates many of the practical considerations.

One straightforward way of driving a single common-anode seven-segment display is shown in Fig. 8. The A side

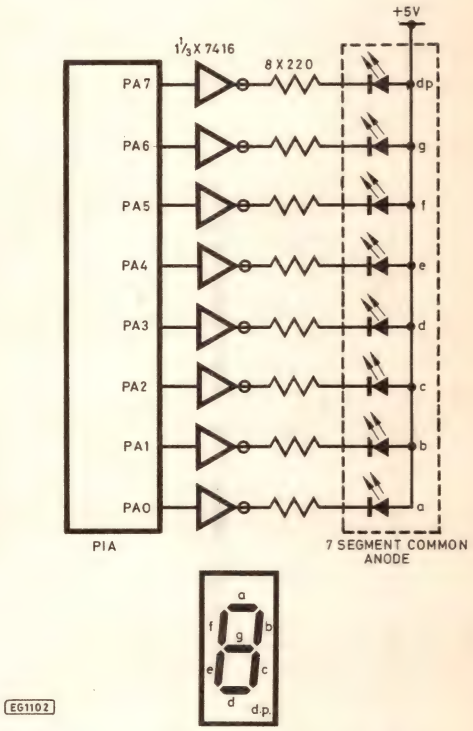


Fig. 8. Driving a single 7-segment display through a PIA

of the PIA is arranged so that one peripheral line is connected to each segment via a buffer stage, which is required to provide the necessary drive capability. Setting any of the PA0 to PA7 lines to a HIGH will cause the corresponding segment to be illuminated, as shown in Table 3 where all values are shown in hexadecimal format. Combinations of segments are selected by writing a value to the PIA register which is equal to the sum of the values for the individual segments. The values which must be written to the PIA to display the standard numerical digits are shown in Table 4.

There are two points which should be noted about this approach when considering its use in practice. The first is that, once a value has been written to the PIA, the display will remain constant until it is changed by the CPU writing a new value. No further CPU action, or by implication program in-

SEGMENT TO BE ILLUMINATED	VALUE WRITTEN TO PIA OUTPUT REGISTER
a	01
b	02
c	04
d	08
e	10
f	20
g	40
d.p.	80

Table 3. PIA output values to illuminate individual segments

NUMBER TO BE DISPLAYED	VALUE WRITTEN TO PIA OUTPUT REGISTER
0	3F
1	06
2	5B
3	4F
4	66
5	6D
6	7D
7	07
8	7F
9	67
A	77
b	7c
C	39
d	5E
E	79
F	71

Table 4. PIA output values for numerical displays

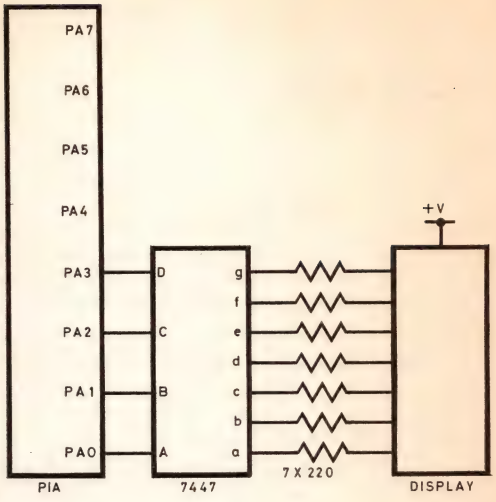


Fig. 10. Alternative scheme for driving a decimal display

added (this may require a loop and test approach in some processors) to the contents of the index register. The index register will now point to the value which must be output to the PIA to display the number required. The display value is then picked up using the index register, and output to the PIA register.

In contrast to the software look-up table, it is possible to use hardware to perform the output processing. Applications which only require to display decimal values, for example, can use a 7447 decoder which will automatically convert decimal inputs into common-anode seven-segment code. Neither a table nor a conversion routine is necessary, and the 7447 will also offer additional features, as shown in Fig. 9 and Table 5. The LAMP TEST input allows all the segments to show if they are working, while the blanking input (BI) turns all the segments off. The ripple blanking input (RBI) and output (RBO) also allow leading and trailing zeroes to be suppressed if required. The simplest way to use the device, however, has the result that fewer PIA peripheral lines are required to drive the display, in addition to the reduction in software required. Fig. 10 shows how the original circuit is simplified for decimal displays; a more flexi-

DECIMAL OR FUNCTION	INPUTS							OUTPUTS						
	LT	RBI	D	C	B	A	BI/RBO	a	b	c	d	e	f	g
0	1	1	0	0	0	0	1	0	0	0	0	0	0	1
1	1	X	0	0	0	1	1	1	0	0	1	1	1	1
2	1	X	0	0	1	0	1	0	0	1	0	0	1	0
3	1	X	0	0	1	1	1	0	0	0	0	1	1	0
4	1	X	0	1	0	0	1	1	0	0	1	1	0	0
5	1	X	0	1	0	1	1	0	1	0	0	1	0	0
6	1	X	0	1	1	0	1	1	1	0	0	0	0	0
7	1	X	0	1	1	1	1	0	0	0	1	1	1	1
8	1	X	1	0	0	0	1	0	0	0	0	0	0	0
9	1	X	1	0	0	1	1	0	0	0	1	1	0	0
10	1	X	1	0	1	0	1	1	1	1	0	0	1	0
11	1	X	1	0	1	1	1	1	1	0	0	1	1	0
12	1	X	1	1	0	0	1	1	0	1	1	1	0	0
13	1	X	1	1	0	1	1	0	1	1	0	1	0	0
14	1	X	1	1	1	0	1	1	1	1	0	0	0	0
15	1	X	1	1	1	1	1	1	1	1	1	1	1	1
BI	X	X	X	X	X	X	0	1	1	1	1	1	1	1
RBI	1	0	0	0	0	0	0	1	1	1	1	1	1	1
LT	0	X	X	X	X	X	1	0	0	0	0	0	0	0

Table 5. Function table for the 7447 decoder/driver

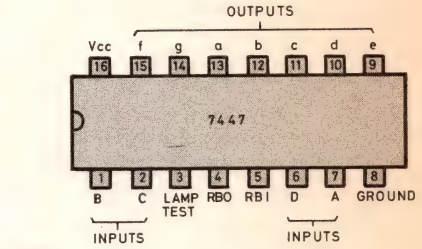


Fig. 9. Pin configuration for the 7447 7-segment decoder/driver

volvement, is required to sustain the display. The second point is that the program which drives the display will have to include, probably as a standard subroutine, a means of converting from a number in a register or memory, into the appropriate value to be output to the PIA. The most common approach to this problem is a look-up table, which is a way of including Table 4 in the control program. The look-up table approach must first ensure that the number to be displayed is within the allowed range; in this case it must be between 0 and F. The index register should then be set to point to the beginning of the table of values which correspond to digits 0 to F; these must be arranged in the order shown in Table 4, with 3F in the first memory location and 71 in the last. The number to be displayed should now be

ble display is obtained if the spare PIA lines are used to drive the control inputs for the 7447.

MULTI-DIGIT DISPLAYS

The single-digit display techniques described above may easily be extended to provide multi-digit displays; in the main it is simply a matter of increasing the number of PIAs used and providing the necessary additional driver hardware. Before very many digits have been added, however, it becomes noticeable that the number of peripheral components and connections required increases in direct proportion to the size of the display. This, in turn, decreases the overall reliability and increases the amount of board space required. A suggested policy is that simple techniques are applicable for displays which can be handled by a single PIA or similar peripheral interface. Beyond this limit, it is probably time to consider the use of intelligent or multiplexed display techniques. Intelligent displays are beyond the scope of this series, but multiplexed displays will usually offer realistic and cost-effective solutions to a wide range of controller display requirements.

Multiplexed displays rely on the fact that the display only needs to appear to be stable for it to be acceptable to the operator, and therefore it does not need to be driven with a 100% duty cycle. Rapid scanning of a display, coupled with the response characteristics of the display (i.e. the light output does not instantaneously fall to zero when the drive voltage is removed), and the afterglow in the operator's retina, means that it is possible to make the CPU scan AND perform other processing tasks apparently simultaneously.

A typical multiplexed seven-segment display configuration is shown in Fig. 11. The 8-digit display is connected between the A and the B sides of a single PIA: The A side determines which of the segments are selected, and the B side determines which of the digits (if any) are actually turned on. To illuminate a particular segment, it must be selected (PA0 to PA7) AND turned on (PB0 to PB7).

More than one segment may be selected at any one time, and more than one digit may be turned on. In normal practice, however, each digit is turned on in sequence, and the display scan routine selects the appropriate segments for that digit position. The single digit display can be thought of as a multiplexed display with one digit permanently turned on, i.e. omit the B side of the PIA and connect the common anode directly to the supply, as shown earlier in Fig. 8.

The display must be scanned often enough to avoid the display flickering, and this usually means that the scan rate is at least 50 to 100 times per second. This may be achieved by including the display scan routine in the main infinite control loop, or by arranging for a regular timer interrupt (every 10 to 20 msec) to initiate a display scan. In many applications the former method may be quite adequate, but the user must be aware that any operation in the main loop which uses a significant amount of time may result in display flicker whenever it is executed. The infinite loop approach does, however, mean that it is possible to trade display flicker against available processing time in applications where a task is not executed often, but when it is run it justifies degradation of display quality.

During each display scan it is normal practice for the scan routine to read from a display table to determine the output values for each digit position. In this way, the remainder of the control software only amends the contents of the display table once each time a change in display is required. This amendment is usually via a standard subroutine which converts the numerical value from the caller into the appropriate display code. The display routine is thus kept separate from the remainder of the control software, and they communicate via a well-defined interface, i.e. the subroutine.

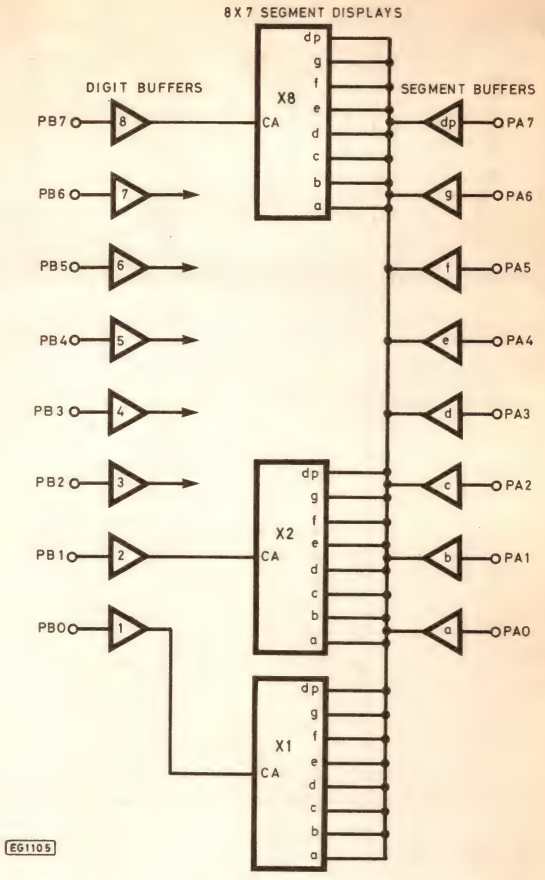


Fig. 11. An 8-digit, 7-segment multiplexed display scheme

For the display shown in Fig. 11, the display scan routine (when invoked) would output the values 01, 02, 04, 08, 10, 20, 40, 80 (hex) to the PIA B output register to select digits 1 to 8 in turn. The interval between changes is set by the time required for the display to achieve usable brightness (typically 1–2 msec), and is usually set by a software delay, although a hardware timer may be used instead if the facilities exist. As each digit is turned on, the corresponding value is read from the display table and output to the PIA A output register. At the end of the cycle it is advisable to turn off all digits, otherwise the last digit (8 in this case) will appear unequally bright.

The multiplexed display combined with the software display table technique has many advantages for the system designer. As far as much of the software is concerned the display appears as a fully latched and decoded unit; the decoding is actually done by the interface subroutine. The hardware, on the other hand, has been kept to a minimum and there is a wide range of multiplexed display hardware available at competitive prices. In all, a good example of a hardware/software tradeoff.

CONCLUSION

This concludes the series on the interfacing and use of microprocessors in real control situations. Of necessity, the subjects covered represent only a small proportion of possible applications. The intention, however, has been to encourage the use of microprocessors in the real world, and to this end the subjects covered should provide a good basis for the development of micro-based projects. ★

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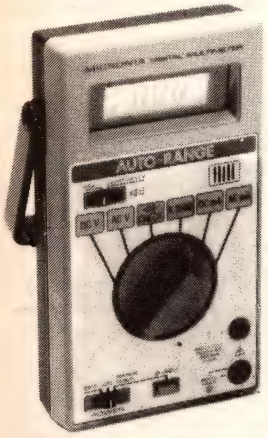

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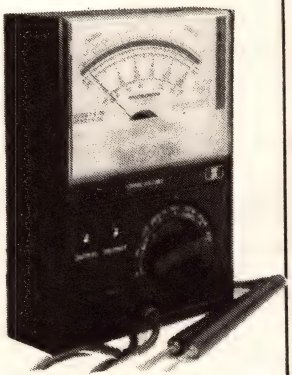

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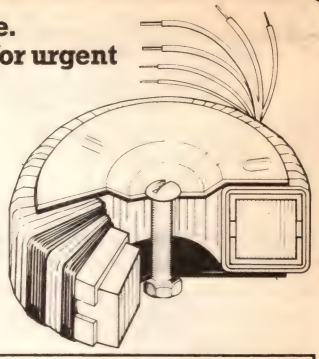

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	2x012	12+12	2.08	
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	2x014	18+18	1.38	+ p&p £1.35
	2x015	22+22	1.13	+ VAT £1.12
	2x016	25+25	1.00	TOTAL £8.60
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
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	3x014	18+18	2.22	+ VAT £1.26
	3x015	22+22	1.81	TOTAL £9.64
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
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	4x012	12+12	5.00	
	4x013	15+15	4.00	**£7.42**
	4x014	18+18	3.33	+ p&p £1.72
	4x015	22+22	2.72	+ VAT £1.37
	4x016	25+25	2.40	TOTAL £10.51
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA 110 x 40mm 1.8Kg Regulation 8%	5x011	9+9	8.89	
	5x012	12+12	6.66	
	5x013	15+15	5.33	
	5x014	18+18	4.44	**£8.43**
	5x015	22+22	3.63	+ p&p £1.72
	5x016	25+25	3.20	+ VAT £1.52
	5x017	30+30	2.66	TOTAL £11.67
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
225 VA 110 x 45mm 2.2Kg Regulation 7%	6x012	12+12	9.38	
	6x013	15+15	7.50	
	6x014	18+18	6.25	
	6x015	22+22	5.11	**£9.81**
	6x016	25+25	4.50	+ p&p £2.05
	6x017	30+30	3.75	+ VAT £1.78
	6x018	35+35	3.21	TOTAL £13.64
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
300 VA 110 x 50mm 2.6Kg Regulation 6%	7x013	15+15	10.00	
	7x014	18+18	8.33	
	7x015	22+22	6.82	
	7x016	25+25	6.00	**£10.88**
	7x017	30+30	5.00	+ p&p £2.05
	7x018	35+35	4.28	+ VAT £1.94
	7x026	40+40	3.75	TOTAL £14.87
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA 140 x 60mm 4Kg Regulation 4%	8x016	25+25	10.00	
	8x017	30+30	8.33	
	8x018	35+35	7.14	**£14.38**
	8x026	40+40	6.25	+ p&p £2.40
	8x025	45+45	5.55	+ VAT £2.52
	8x033	50+50	5.00	TOTAL £19.30
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA 140 x 75mm 5Kg Regulation 4%	9x017	30+30	10.41	
	9x018	35+35	8.92	
	9x026	40+40	7.81	**£17.12**
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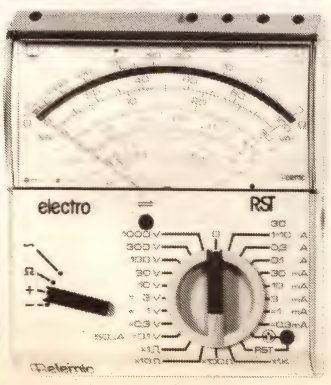

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USER MONITOR ROUTINES

THERE will be many applications where peripheral hardware connected to the Microcontroller will require a regular opportunity to gain a share of the CPU processing time to perform some function, but without using interrupts. An example might be to maintain a continuous display of elapsed time on a 4-digit l.e.d. module connected to a user PIA, using the value of TICK which is held in DISBUG RAM. The majority of the processing required would be to refresh the l.e.d. digits in a similar fashion to that employed by DISBUG. Such a task could be performed by writing a user routine and using all of the available CPU time to perform it. This approach, although successful, would tie up the total CPU resources for what is essentially a 'background' task. The Microcontroller is capable of excuting more than 200,000 typical instructions every second, so it should be possible to perform some sort of background servicing at the same time as providing the normal DISBUG facilities.

The overall design of the infinite control loop in the top-level DISBUG routine was shown in Part 3 of the Microcontroller series. The code for this routine occupies twenty bytes, starting at the bottom of the EPROM at location F8ØØ, and is shown below. It can be seen that, just before jumping back to restart the loop, a user-defined monitor routine is called in the main loop. Once again this makes use of a software vector held in DISBUG RAM (UMRSA at location Ø3C4, 2 bytes long). At start-up the initialisation routine initialises this vector to point to a default service routine at F82B, which is simply an RTS instruction, and therefore the call has no effect other than a slight delay. Since the vector is held in RAM, however, this can easily be overwritten to define an alternative service routine; the technique is identical in concept to that used for the PF1 and PF2 keys, see Data Sheet 2.

User-defined monitor routines are written as subroutines, and must end with an RTS instruction. Once the start address in user RAM has been placed in Ø3C4/5 (UMRSA), the routine will be called every time round the monitor loop. No call will be made, however, when the keyboard scan produces an uncertain result; this is to avoid misleading results. On entry to the user routine, the state of all registers except SP will be undefined. The stack pointer will set to just below the top of the DISBUG stack area, with at least 1A bytes of unused stack space available. Users should allow for a further 7 bytes to be set aside for RTC and other interrupts, leaving 13 (hex) bytes of stack space for the user routine. This will allow the use of multi-level subroutines, which may include calls to previously described DISBUG routines, and also allows local temporary storage of variables on the stack.

```
DISBUG:  BSR   DISPLAY    ; Refresh the display
         BSR   KEYBOARD   ; Scan the keyboard keys
         CMPB  #FF        ; Uncertain scan result?
         BEQ   DISBUG     ; Yes—ignore this scan
         BSR   KEYCODE    ; No—convert to code
         JSR   COMPROC    ; Call command processor
         LDX   UMRSA      ; Call the user-defined
         JSR   ØØ,X       ; . . monitor routine
         BRA   DISBUG     ; Re-start the loop
```

DISBUG top level control routine

The addition of a user-defined routine to the existing monitor, in the form of either a single routine or a nested suite of routines, allows the facilities of the basic monitor to be extended to suit particular applications. By suitable programming, the user PIAs may even be configured to allow the use of extra keyboards and/or displays.

INTERRUPT SERVICE ROUTINES

Whenever a user interrupt is recognised by the 6800 (i.e. IRQ asserted and user interrupts not masked out), the CPU saves the registers on the stack, masks out further interrupts, and jumps to the address contained in locations FFF8 and FFF9. In DISBUG, these two locations point to a routine called IRQINT at location FF9Ø, and the code for this routine is shown below. IRQINT first of all checks to see if the interrupt was caused by an RTC 'tick', and if so it increments TICK in DISBUG RAM and resets the appropriate display PIA interrupt flag. The second action of IRQINT is to jump, using the software vector from IRQSRA (Ø3DC and Ø3DE in DISBUG RAM), to the user interrupt service routine for any further interrupt processing required. The IRQSRA vector is set up by the DISBUG initialisation routine to point to DEFISR (see below), which simply dismisses the interrupt and returns to the original program in the usual way.

Users may define their own additional interrupt processing by overwriting the vector in IRQSRA with the appropriate start address. The user-supplied routine should be written as a handler which terminates in an RTI instruction. On entry to such a user-defined routine, RTC interrupts will have been handled, but user interrupts will still be masked.

```
IRQINT:  LDA A DPIACRB   ; Read RTC int flag
         BGE NOTICK      ; Has clock ticked?
         LDX TICK        ; Yes . . .
         INX             ; . . . update the . . .
         STX TICK        ; . . . tick count
         LDA B DPIADRB   ; Reset int flag
NOTICK:  LSX IRQSRA      ; Call the user . . .
         JMP ØØ,X        ; . . . service routine
DEFISR:  RTI             ; Default routine
```

DISBUG interrupt service routine

DISBUG MEMORY MAP

The following brief memory map highlights some of the more significant routines within DISBUG for the benefit of the experimenter and enthusiastic disassembler. All except those marked with an asterisk are written as subroutines.

```
F8ØØ DISBUG          F98F RESTART
F814 DISPLAY         F9EE REGISTER
F82C KEYBOARD        FACD MEMORY
F85D SCANKB          FC91 PRESET
F86D IDKEY          *FD3F SWINT
F877 KEYCODE         FD9C PROCEED
F8BC DISDELAY        FDF8 NMINT
F8C6 KBDELAY         FEØØ GO
F8DØ DIGIT           FE76 BREAKPT
F8F7 TWODIG         *FFØØ INIT
                     FF77 WELCOME
F918 COMPROC        *FF9Ø IRQINT
F96B KEYLATCH       *FFF8 Interrupt
F984 PF1                  Vectors
F989 PF2
```

M. Tooley BA and D. Whitfield MA MSc

Ultimum Computer Interface Part 7

WILLIAM EDWARDS WATFORD ELECTRONICS

TO COMPLETE the series of sound generating peripherals, we describe a nine channel sound card complete with amplification. The card makes use of the General Instrument "sound chip" (three to be precise) which can be programmed to generate a wide range of sounds. The chip has been around for some time, which makes it a cheap and reliable way to convert bytes into musical (or totally non-musical) audio signals.

THE AY–3–8910

The sound chip is programmed via a set of internal registers. The 40-pin package leaves a lot of spare lines which have been allocated to parallel ports, so as a bonus, the card offers five, 8 bit ports which can be set up as inputs or outputs. These lines are TTL compatible.

In each chip there are three tone generators, which use programmable counters to determine the period of the tone. As these counters are 12 bits long, a reasonably accurate representation of the "well tempered" musical scale can be generated. The three generators can be used quite independently, or rather like the organ, they can be mixed to provide a complicated tone made up of synthesised harmonics, which gives added colour to the sound produced.

Each tone generator is fed into an envelope generator made out of a 4 bit D-to-A. The amplitude of each channel can be set, or provide some shaping by varying the amplitude with time. Some useful envelopes are pre-programmed into the chip, keeping the amount of external programming to a minimum.

In addition to the tones, a noise generator is provided. It is possible to colour the noise by setting a 5 bit time period in one of the internal registers, so that sounds from a low roar to a hiss are possible, very useful for games.

Two 8-bit ports are accessed by other registers in the chip. Each port can be set to all inputs or outputs.

THE CIRCUIT

Fig. 7.1 shows the circuit for the sound card. It is made up of an interface to the motherboard (decoding and a parallel port—the now familiar 8255), three AY–3–8910 sound chips and a low power amplifier to reproduce the sound through a small speaker. There is a pick-off for external amplification, but the highly "in-phase", square wave signals produced by most computer sound generators is not well suited to your best hi-fi as the signals impose a heavy load on the amplification and speakers. The port occupies four memory locations, the decoding allows one to map this area

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R5, R6	4k7 (2 off)
R7	10

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Potentiometers

VR1	1k hor. 100mW preset

Capacitors

C1	20p ceramic
C2	10µ 16V tant.
C3, C7–19	100n ceramic (14 off)
C4–6	4µ7 16V tant. (3 off)

Integrated Circuits

IC1–4	74LS85 (4 off)
IC5	8255
IC6	74LS13
IC7–9	AY–3–8910
IC10	LM386
IC11	4013B
IC12	4011B
IC13, 14	8 x 4k7 s.i.l. resistor

Miscellaneous

S1 P.c.b. mounting low profile keyboard switch & cap
TB1 4-way p.c.b. mounting terminal block
2 x 32-way A + C male right-angle DIN41612
WE07 SBD printed circuit board
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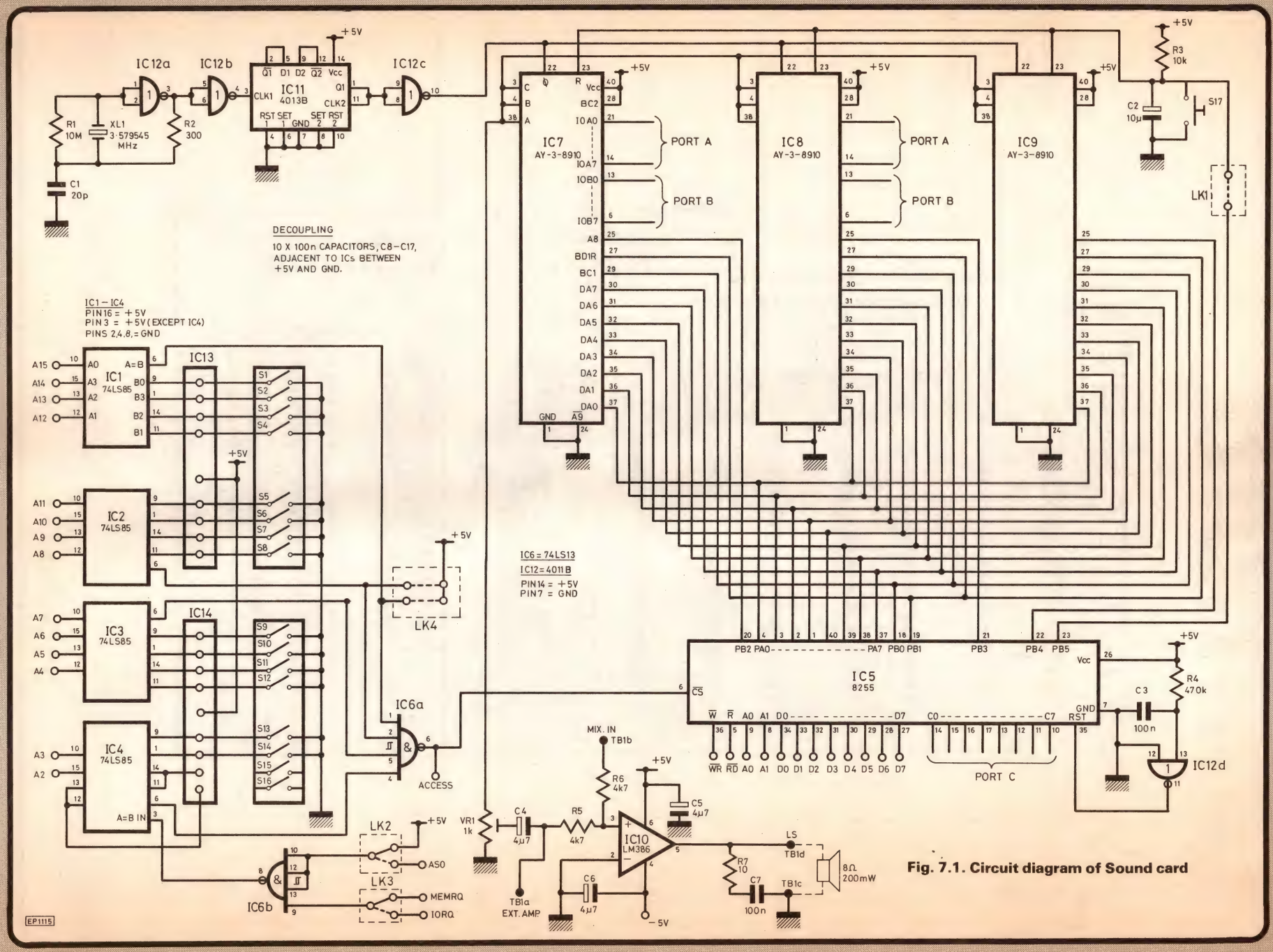

Fig. 7.1. Circuit diagram of Sound card

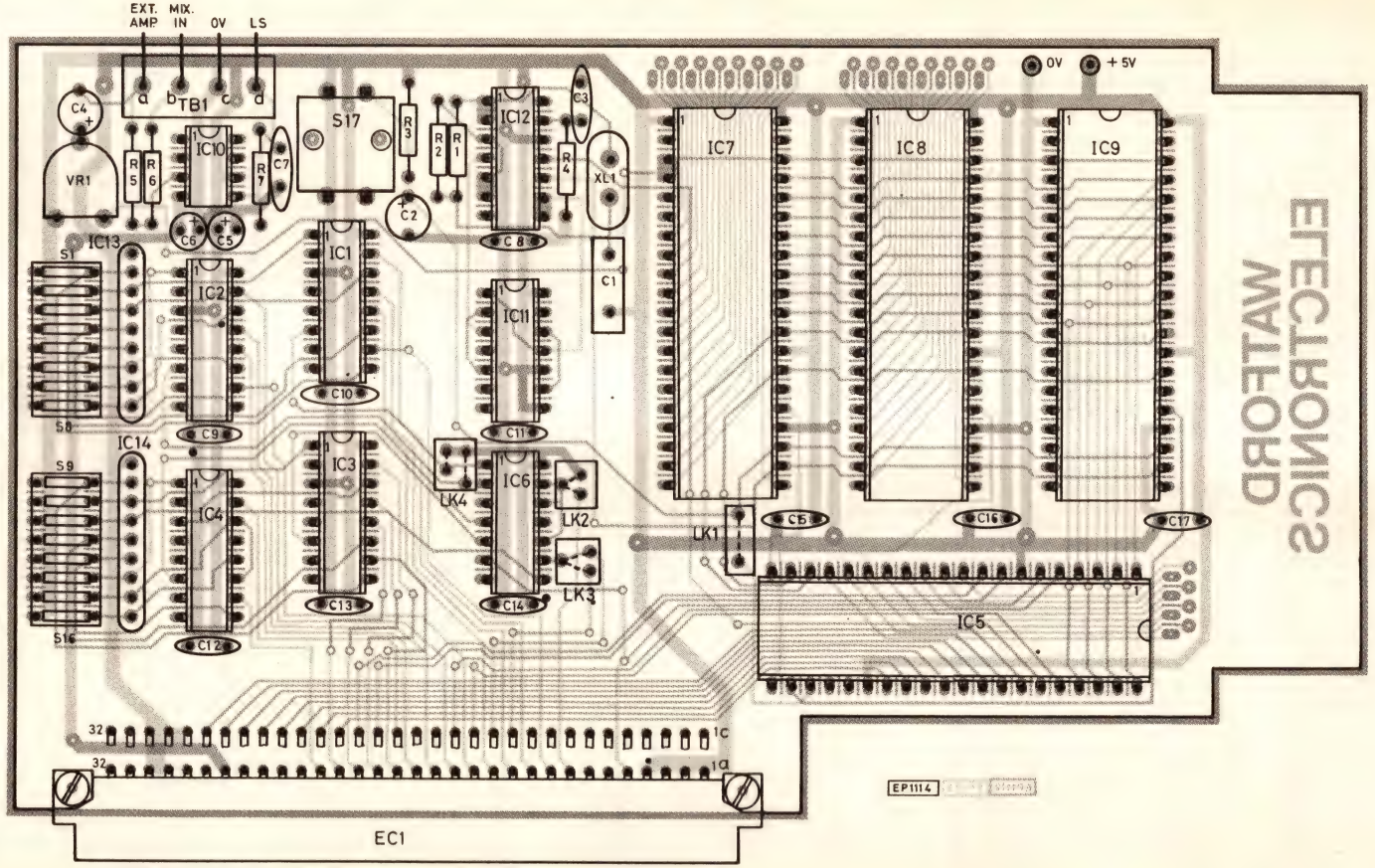

Fig. 7.2. Component layout

```
 10 P=....                    REM LOCATION OF 8255
 20 POKE P+3,128              REM SET UP ALL PORTS
                              FOR OUTPUT
 30 POKE P+1,32               REM RESET SOUND CHIPS
 40 C=1                       REM SET UP FOR FIRST
                              CHIP
 50 R=7                       REM REGISTER 7 —
                              ENABLE
 60 D=254                     REM SOUND ON
                              CHANNEL A
 70 GOSUB 200                 REM CALL THE REGISTER
                              DATA ENTRY ROUTINE
 80 R=8                       REM CHANNEL A
                              AMPLITUDE
 90 D=15                      REM FULL VOLUME
100 FOR L1=2 TO 0 STEP -1
110 R=1                       REM CHANNEL A COARSE
                              TUNE
120 D=L1
130 GOSUB200
140 R=0                       REM FINE TUNE
150 FOR D=255 TO 0 STEP -1
160 GOSUB 200
170 NEXT D
180 NEXT L1
190 END
200 POKE P,R                  REM STORE REGISTER
210 POKE P+1,2^(C+1)+3        REM SELECT CHIP TO
                              RECEIVE ADDRESS
220 POKE P+1,0                REM DESELECT CHIP
230 POKE P,D                  REM STORE DATA
240 POKE P+1,2^(C+1)+2        REM SELECT CHIP TO
                              RECEIVE DATA
250 POKE P+1,0                REM DESELECT
260 RETURN
300 REM VALID RANGES FOR C, R AND D
310 REM D BETWEEN 0 AND 255
320 REM R BETWEEN 0 AND 15
330 REM C BETWEEN 1 AND 3
```

Table 7.1. BASIC test program

```
 10 P=....                    REM ADDRESS OF 8255
 20 POKE P+3,128              REM ALL PORTS AS
                              OUTPUT
 30 POKE P+1,32               REM RESET SOUND CHIPS
 40 INPUT "CHIP"; C           REM COLLECT
 50 INPUT "REGISTER"; R       REM RELEVANT
 60 INPUT "DATA"; D           REM INFORMATION
 70 POKE P,R                  REM STORE REGISTER
 80 POKE P+1,2^(C+1)+3        REM STROBE ADDRESS
 90 POKE P,O                  REM CLEAR STROBE
100 POKE P,D                  REM STORE DATA
110 POKE P+1,2^(C+1)+2        REM STROBE DATA
120 POKE P+1,0                REM CLEAR STROBE
130 GOTO40
```

Table 7.2. Register access program

to anywhere in memory by setting switches (1–14). For ease of description we have continued to use the 8255 (there is one on most of the cards in this series, including the motherboard). Setting up the card is a matter of setting up this port and then writing to the AY–3–8910 registers via the control lines PA0–PA7 and PB0–PB4. A push button on the board allows you to reset the board. On power up, reset is automatic, but you can use PB5 to make reset possible from the host system, by setting link 1.

(a) $f_T = \frac{f_{CLOCK}}{16TP_{10}}$ (b) $TP_{10} = 256CT_{10} + FT_{10}$

Where: f_T = desired tone frequency
f_{CLOCK} = input clock frequency
TP_{10} = decimal equivalent of the Tone Period bits TP11–TP0
CT_{10} = decimal equivalent of the Coarse Tune register bits B3–B0 (TP11–TP8)
FT_{10} = decimal equivalent of the Fine Tune register bits B7–B0 (TP7–TP0)

From the above equations it can be seen that the tone frequency can range from a low of $\frac{f_{CLOCK}}{65,520}$ (wherein: $TP_{10} = 4,095_{10}$) to a high of $\frac{f_{CLOCK}}{16}$ (wherein: $TP_{10} = 1$). Using a 1·7MHz input clock, for example, would produce a range of tone frequencies from 27Hz to 111kHz.

To calculate the values for the contents of the Tone Period Coarse and Fine Tune registers, given the input clock and the desired output tone frequencies, we simply rearrange the above equations, yielding:

(a) $TP_{10} = \frac{f_{CLOCK}}{16f_T}$ (b) $CT_{10} + \frac{FT_{10}}{256} = \frac{TP_{10}}{256}$

Table 7.3. Tone frequency formulae

	position	
Link 1	open	power-up and manual reset
	made	software reset vice 8255—omit PB1, R3, C2
Link 2	default	board always in address space
	alternative	board may be mapped in and out by motherboard 8255
Link 3	default	board is memory mapped
	alternative	board is I/O mapped
Link 4 (pair)	open	memory mapped
	made	I/O mapped—omit IC1,2,13 and S1–8

Table 7.4. Link functions

CONSTRUCTION

Refer to the overlay (Fig. 7.2). This is a simple board to assemble. Use sockets for the i.c.s. These make repair etc. much easier. The crystal should not have its leads bent at the base as this might damage the housing.

Set the switches 1–14 by determining the area in memory to which the board is to be mapped (say 4120H), then translate this into binary (0100000100100000) discard the least significant two bits (01000001001000). For each zero in the pattern, turn on the corresponding switch (S0, in this case). Switches 14, 12, 11, 10, 9, 8, 6, 5, 3, 2, 1 are on.

If you want to reset the board via the 8255, short link 1, but leave out C2.

TESTING

The AY–3–8910 is a little more tricky to set up, because of its large number of registers. Obtain the data sheet for the internal register layout of this chip. The BASIC program of Table 7.1 is a commented test program which shows how the tone registers are set up. Table 7.2 gives details of how each individual register is accessed on each sound chip. Table 7.3 shows the simple formulae needed to calculate a particular tone, given the colour burst crystal supplied with the sound board. For more complicated applications, a full manufacturer's data sheet, complete with examples, is available with the kit, see Components List.

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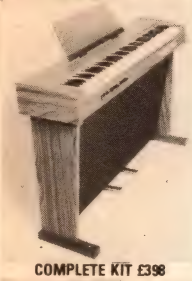

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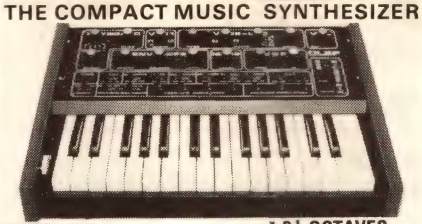

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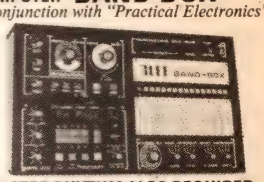

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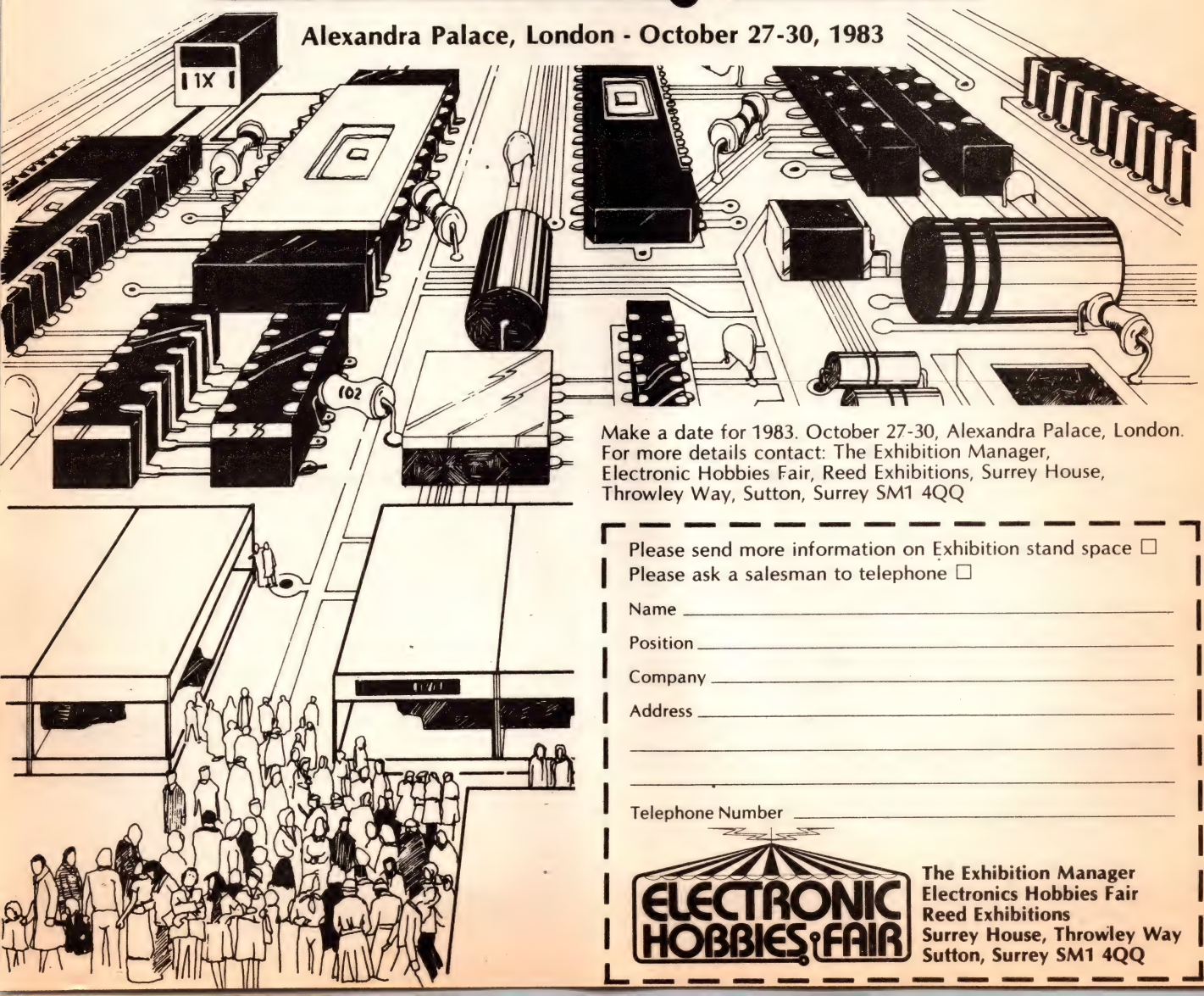

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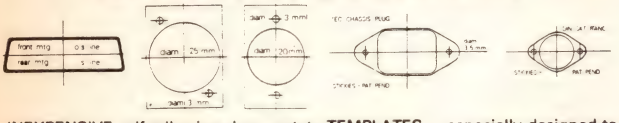

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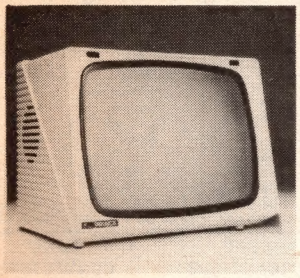

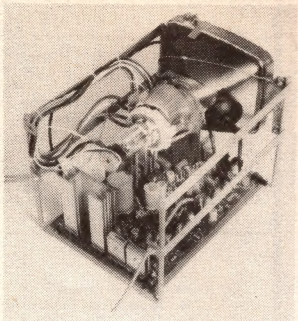

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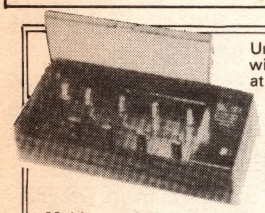

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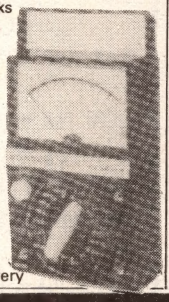

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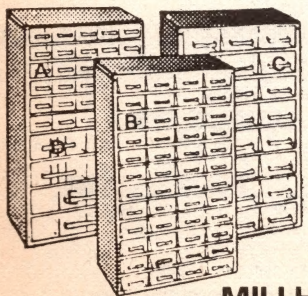

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A.D. Electronics 74
Ambit 4
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Bicc Vero 12
Bi-Pak 14
Blackstar Limited 68
British National Radio & Electronics School 4, 20

Cambridge Learning 8
Centurion Alarms 77
Clef Products 74
Colne Robotics 41
Cricklewood Electronics 9
Crofton 79
The C.R. Supply Co. 76

Electronics World 76
Electrovalue 13
Enfield Electronics 79

Futronics 77

Grenson (EMOS) 78
G.S.C 61

Adam Hall Supplies Ltd. 77
Hameg 54

ICS Intertext 79
I.L.P. Electronics 6, 7, 68

London College 77

Maplin Electronics ..... Cover 4
Mercia 4
Midwich 33
Millhill Supplies 79
Modern Book Co. 78
Myers Electronics 76

Parndon Electronics 4
Phonosonics 12
Pimac 77
P.K.G. Electronics 77
Powertran ..... Cover 2

Radio Component Specialists 78
Radio & T.V. Components 54
Riscomp Ltd. 20

Scientific Wire Co. 77
Sifam 10
Sparkrite 5
Swanley 10

Tandy 67
Technomatic Ltd. .....80, Cover 3
T.K. Electronics 11

Vachettes Micros 76
Videotone 61

Watford Electronics 2, 3
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'417	18p
'420	14p
'421	18p
'422	20p
'423	18p
'425	18p
'426	18p
'427	18p
'428	18p
'430	14p
'432	18p
'433	22p
'437	22p
'438	22p
'440	15p
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'442A	30p
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'446A	50p
'447A	36p
'448	45p
'450	15p
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74145	40p
74147	75p
74148	60p
74150	50p
74151A	36p
74153	36p
74154	50p
74155	36p
74156	40p
74157	30p
74159	75p
74160	40p
74161	40p
74162	40p
74163	40p
74164	45p
74165	45p
74166	48p
74170	120p
74172	250p
74173	50p
74174	55p
74175	50p
74176	40p
74177	45p
74178	70p
74180	40p
74181	115p
74182	40p
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74185A	90p
74186	470p
74188	250p
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74192	45p
74193	45p
74194	40p
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74LS22	13p
74LS26	14p
74LS27	13p
74LS28	14p
74LS30	13p
74LS32	13p
74LS33	14p
74LS37	14p
74LS38	14p
74LS42	30p
74LS47	36p
74LS48	45p
74LS51	14p
74LS55	14p
74LS73	18p
74LS74	16p
74LS75	18p
74LS76	18p
74LS83	36p
74LS85	40p
74LS86	16p
74LS90	22p
74LS92	30p
74LS93	22p
74LS95	40p
74LS96	50p
74LS107	20p
74LS109	27p
74LS112	20p
74LS113	20p
74LS114	22p
74LS122	25p
74LS123	34p
74LS124	90p
74LS125A	24p
74LS126A	25p
74LS132	34p
74LS133	25p
74LS136	25p
74LS138	27p
74LS139	27p
74LS145	70p
74LS147	100p
74LS148	75p
74LS151	40p
74LS153	40p
74LS154	80p
74LS155	30p
74LS156	36p
74LS157	25p
74LS158	30p
74LS160A	36p
74LS161A	36p
74LS162A	36p
74LS163A	36p
74LS164	40p
74LS165A	50p
74LS166A	60p
74LS168	85p
74LS169	85p
74LS170	70p
74LS173A	55p
74LS174	45p
74LS175	40p
74LS181	90p
74LS190	36p
74LS191	36p
74LS192	36p
74LS193	36p
74LS194A	35p
74LS195A	35p
74LS196	45p
74LS197	45p
74LS221	50p
74LS240	55p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	55p
74LS245	70p
74LS251	30p
74LS253	40p
74LS256	150p
74LS257	30p
74LS258	35p
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40163	60p
40174	50p
40175	50p
40193	60p

14495	300p
14599	290p

LINEAR I.Cs

AN103	200p
AY1-0212	600p
AY1-1320	225p
AY1-5050	99p
AY3-8910	380p
AY3-8912	625p
AY5-1350	350p
AY5-4007D	600p
CA3028A	120p
CA3019	80p
CA3046	70p
CA3048	220p
CA3059	285p
CA3080E	70p
CA3086	48p
CA3089E	200p
CA3090AQ	375p
CA3130E	90p
CA3140E	40p
CA3160E	100p
CA3161	150p
CA3162E	450p
CA3189E	300p
CA3240E	110p
CA3280G	200p
DAC1408-8	200p
HA1366	195p
HA1388	250p
ICL7106	700p
ICL7660	£2
ICL8038	300p
LC7120	300p
LC7130	350p
LC7137	270p
LF347	150p
LF351	45p
LF353	95p
LF356P	95p
LF357	110p
LM10C	325p
LM301A	25p
LM310	120p
LM311	70p
LM318	300p
LM319	215p
LM324	30p
LM335Z	140p
LM339	50p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	90p
LM387	120p
LM389	95p
LM393	100p
LM394CH	300p
LM709	36p
LM710	50p
LM711	170p
LM725	300p
LM733	60p
LM741	18p
LM747	70p
LM748	35p
LM1871	300p
LM1872	300p
LM1886	700p
LM1889	350p
LM2917	200p
LM3302	75p
LM3900	50p
LM3909	85p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
M51513L	230p
M51516L	500p
MB3712	200p
MC1310P	150p
MC1413	100p
MC1458	36p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	65p
MK50240	£9
MK50938	635p
MM57160	620p
NE531	140p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
NE571	400p
NE5534A	125p
PLL02A	500p
RC4136	60p
RC4151	200p
RC4558	60p
S566B	225p
S50240	900p
SAD1024A	850p
SFF96364	800p
SL490	350p
SN76477	450p
SP8515	750p
TA7120	150p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA621AX1	275p
TBA641BX1	300p
TBA800	80p
TBA810	100p
TBA820	80p
TBA920	200p
TBA950	225p
TC9109	750p
TCA210	350p
TCA220	350p
TCA940	175p
TDA1004A	300p
TDA1008	320p
TDA1010	200p
TDA1022	500p
TDA1024	120p
TDA1170	300p
TDA2002V	300p
TDA2003	325p
TDA2020	320p
TL071/81	25p
TL072/82	45p
TL064/74	95p
TL084	90p
TLu94	200p
TL430C	70p
UAA170	170p
UA2240	120p
ULN2003A	75p
UPC1156H	275p
XR2206	300p
ZNA134	£23
ZNA234	850p
ZN414	80p
ZN419C	190p
ZN424E	130p
ZN425E	340p
ZN427E	580p
ZN428E	400p
ZN1034E	200p
ZN1040E	670p

CPUs

1802CE	650p
2650A	£12
6502	350p
6502A	500p
6800	225p
6802	225p
6809	650p
6809E	£12
68B09	£12
8035	350p
8039	£3
8080A	250p
8085A	450p
8748	£16
INS8060	£11
TMS9980	£20
Z8	£24
Z80	290p
Z80A	320p
Z80B	£12
8088	£18
TMS5100	£10
TMS9995	£12

SUPPORT DEVICES

3242	800p
3245	450p
6520	280p
6522	350p
6522A	550p
6532	550p
6551	650p
6821	100p
68B21	220p
6840	375p
68840	650p
6850	110p
68B50	220p
6852	250p
6854	770p
6875	500p
8154	950p
8155	350p
8156	350p
8205	225p
8212	110p
8216	100p
8224	110p
8226	250p
8228	220p
8243	280p
8250	850p
8251	250p
8253	390p
8255	255p
8256	£36
8257	£4
8259	£4
8279	440p
8284	350p
8288	100p
8755A	£15
Z80PIO	250p
Z80APIO	280p
Z80CTC	250p
Z80ACTC	250p
Z80ADART	£7
Z80ADMA	£10
Z80SIO-0/1/2	£9

CRT CONTROLLER

CRT6545	900p
CRT5027	£18
CRT5037	£18

EF9365	£48
EF9366	£48
MC6845	650p
MC6847	650p
SFF96364	£8
TMS9918	£60
TMS9927	£18
TMS9929	£20

ZIF SKTS (TEXTOOL)

24 pin	£6
28 pin	£8
40 pin	£10

MEMORIES

2101A	400p
2102-3L	120p
2107B	500p
2111A	300p
2112-A	300p
2114-2L	100p
2147	450p
4027-3	300p
4116-15	120p
4116-20	100p
4118-3	500p
4118-4	450p
4164-2	500p
4164-15(TI)	£4
4816AP-3	280p
5101	210p
5516	850p
6116P-3	420p
6116LP-3	550p
6514	250p
6810	120p
7489	180p
74S189	150p
74S201	350p
74S289	150p
93415	600p
93425	600p

ROMs/PROMs

74S188	150p
74S225	550p
74S287	225p
74S288	150p
74S387	225p
74S471	650p
74S473	650p
74S474	400p
74S570	650p
74S571	650p
74S573	900p

EPROMs

2516 (+5V)	250p
2532	375p
2564	£12
2708	250p
2716 (+5V)	250p
2732	450p
2716 (350ns)	500p
2732 (300ns)	750p
TMS2716	750p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	450p
TR1602	300p

INTERFACE ICs

AD558CJ	775p
AD561J	£20
AD7581	1150p
AM25S10	350p
AM25LS2521	£2
AM26LS31	125p
AM26LS32	125p
DAC80	£28
DM8131	275p
DP8304	250p
DS8830	140p
DS8831	140p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	55p
MC1489	55p
MC3446	300p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
ULN2003A	75p
75107	90p
75108/9	90p
75110/12	90p
75114/15	160p
75121/22	140p
75150P	120p
75154	140p
75182	90p
75324	375p
75361	150p
75363	150p
75365	150p
75451/2	72p
75453/4	72p
75491/2	65p
8T26	120p
8T28	120p
8T95/96	90p
8T97/98	90p
81LS95	80p
81LS96	80p
81LS97	80p
81LS98	80p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E-8	650p
ZN428E-8	500p

DISC CONTROL ICs

FD1771	£20
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
WD1691	£15
WD2143	550p
8271	£36

CHARACTER GENERATORS

RO-3-2513UC	750p
RO-3-2513LC	700p
SN74S262AN	£10
MC66760	750p

CRYSTALS

32·768KHz	100p
100KHz	250p
200KHz	280p
1·0MHz	290p
1·008MHz	275p
1·5MHz	450p
1·8432MHz	210p
2·00MHz	225p
2·45760MHz	210p
2·5MHz	250p
2·662MHz	250p
3·276MHz	150p
3·5795MHz	100p
3·686MHz	300p
4·00MHz	150p
4·194MHz	200p
4·43MHz	110p
4·608MHz	250p
4·9152MHz	250p
5·00MHz	175p
6·00MHz	150p
6·144MHz	150p
7·00MHz	150p
7·168MHz	175p
8·00MHz	175p
8·86MHz	175p
10·00MHz	175p
10·50MHz	250p
10·70Hz	150p
12·00MHz	150p
14·318M	175p
14·756MHz	250p
15·00MHz	200p
16·00MHz	200p
17·7MHz	200p
18·00MHz	200p
18·432MHz	150p
19·968MHz	150p
20·000MHz	200p
26·690MHz	150p
27·145MHz	200p
38·6667MHz	175p
48·0MHz	175p
55·5MHz	400p
116MHz	300p
145.80MHz	250p

KEYBOARD ENCODER

AY-5-2376	700p
74C922	420p
74C923	500p

MODULATORS

6MHz UHF	375p
8MHz UHF	450p

BAUD RATE GENERATOR

MC14411	675p
COM8116	700p
4702B	750p

TELETEXT DECODER ICs

SAA5020	£6
SAA5030	£9
SAA5041	£16
SAA5050	£9

REAL TIME CLOCK

MM58174	800p
MCM66760	700p

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

VOLTAGE REGULATORS FIXED PLASTIC

1A	+ve		−ve	
5V 1A	7805	•40p	7905	45p
12V 1A	7812	•40p	7906	45p
15V 1A	7815	•40p	7912	45p
18V 1A	7818	•40p	7915	45p
24V 1A	7824	•40p	7918	45p
5V 100mA	78L05	30p	7924	45p
12V 100mA	78L12	30p	79L05	65p
15V 100mA	78L15	30p	79L12	50p

OTHER REGULATORS

LM309K 1A 5V	135p	78HGKC	600p
LM317K	325p	78H05KC	550p
LM317T 1A Adj	220p	78MGT2C	140p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	450p	79GUIC	225p
LM723 150mA Adj	37p	79HGKC	700p
TL494	400p	TL497	300p
78S40	300p	LM305H	250p

OPTO-ELECTRONICS

2N5777	45p	ORP12	120p
OCP71	180p	ORP60	120p
		ORP61	120p
		TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL 111	70p
MCT26	100p	TIL 112	70p
MCS2400	190p	TIL 113	70p
ILQ74	240p	TIL 116	70p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	10p
TIL209 Red	10p	TIL222 Gr	12p
TIL211 Gr	12p	TIL228 Yel	15p
TIL212 Ye	15p	Rectangular	
TIL216 Red	18p	LEDs (R, G, Y)	30p
		NSB5881	670p
		TIL311	600p
		TIL312/3	110p
		TIL321/2	130p

DISPLAYS

DL704	140p	TIL330	140p
DL707 Red	140p	7750/60	200p
FND357	120p		
FND500	90p		
FND507	90p		
MAN3640	175p		
MAN4640	200p		

DRIVERS

9368	250p		
9370	300p		
UDN6118	320p		
UDN6184	320p		

TRANSISTORS

AD161/2	40p	BFR79	20p	MPSU65	78p	2N1711	25p
BC107/8	14p	BFR80/1	25p	TIP29A/B	35p	2N2102	70p
BC108B	15p	BFX29	40p	TIP29C	40p	2N2160	295p
BC109C	16p	BFX30	34p	TIP31C	50p	2N2219A	25p
BC169C	10p	BFX84	25p	TIP32A	40p	2N2222A	25p
BC172	12p	BFX85	30p	TIP32B	45p	2N2369A	17p
BC177/8	17p	BFX88	25p	TIP32C	50p	2N2484	25p
BC179	18p	BFX89	150p	TIP33A	60p	2N2646	40p
BC182/3	10p	BFY50	24p	TIP33B	65p	2N2904/5	25p
BC184	10p	BFY51/2	24p	TIP33C	70p	2N2906A	25p
BC187	30p	BFY56	30p	TIP34A	65p	2N2907A	25p
BC212/3	10p	BFY90	80p	TIP34B	70p	2N2926	9p
BC214	12p	BRY39	40p	TIP34C	80p	2N3053	25p
BC237	10p	BSX19/20	24p	TIP35A	120p	2N3054	55p
BC327	16p	BU104	225p	TIP35B	140p	2N3055	45p
BC337	10p	BU105	190p	TIP35C	150p	2N3442	140p
BC338	15p	BU108	250p	TIP36A	140p	2N3553	240p
BC461	30p	BU109	225p	TIP36B	150p	2N3584	250p
BC477/8	30p	BU126	150p	TIP36C	160p	2N3643/4	48p
BC516/7	36p	BU180A	120p	TIP41A	45p	2N3702/3	10p
BC547B	12p	BU205	175p	TIP41B	50p	2N3704/5	10p
BC548C	12p	BU208	200p	TIP41C	55p	2N3706/7	14p
BC549C	12p	BU406	145p	TIP42A	50p	2N3708/9	12p
BC557B	14p	BUX80	400p	TIP42B	45p	2N3773	300p
BC559C	16p	J310	50p	TIP42C	60p	2N3819	25p
BCY70	20p	MJ802	400p	TIP54	160p	2N3820	40p
BCY71/2	20p	MJ2501	225p	TIP120/22	60p	2N3823	50p
BD131	60p	MJ2955	90p	TIP142	110p	2N3866	90p
BD132	40p	MJ3001	225p	TIP147	120p	2N3902	700p
BD135	40p	MJE340	50p	TIP2955	60p	2N3903/4	16p
BD136	35p	MJE2955	90p	TIP3055	60p	2N3905/6	16p
BD139	40p	MJE3055	70p	VN10KM	55p	2N4037	65p
BD140	40p	MPF102/3	30p	VN66	80p	2N4123/4	27p
BD189	60p	MPF104/5	30p	ZTX108	10p	2N4125/6	27p
BD242A	60p	MPF105	30p	ZTX300	13p	2N4401/3	25p
BD379	40p	MPSA06	30p	ZTX500	13p		
BD380	40p	MPSA12	50p	ZTX502	15p		
BF244B	25p	MPSA13	50p	ZTX504	18p		
BF256B	50p	MPSA20	50p	2N697	20p		
BF257/8	30p	MPSA42	50p	2N698	40p		
BF259	35p	MPSA43	50p	2N706A	18p		
BF337	30p	MPSA56	25p	2N708	18p		
BFR39	20p	MPSA70	50p	2N918	35p		
BFR40/1	20p	MPSU06	55p	2N930	18p		
		MPSU07	60p	2N1131/2	36p		
		MPSU45	90p	2N1613	30p		

2N4427	90p	1A 50V	70p	2.7V-33V			
2N4871	50p	1A 400V	90p	400mW	9p		
2N5087	27p	3A 400V	100p	1W	15p		
2N5089	27p	8A 600V	140p				
2N5172	18p	12A 400V	160p				
2N5191	70p	12A 500V	105p				
2N5194	75p	16A 400V	110p				
2N5245	40p	16A 500V	130p				
2N5296	65p	T2800D	130p				
2N5401	50p						
2N5457/8	32p						
2N5459	32p						
2N5460	60p						
2N5485	36p						
2N5875	250p						
2N6027	30p						
2N6052	300p						
2N6059	325p						
2N6107	65p						
2N6247	190p						
2N6254	130p						
2N6290	65p						
2SC1172	150p						
2SC1306	150p						
2SC1307	150p						
2SC1957	90p						
2SC2969	198p						
2SC2028	120p						
2SC2029	250p						
2SC2078	200p						
3N128	120p						
3N140	120p						
3N141	110p						
3N201	110p						
3N204	120p						

DIODES

BY127	12p
OA47	9p
OA90/91	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	5p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p

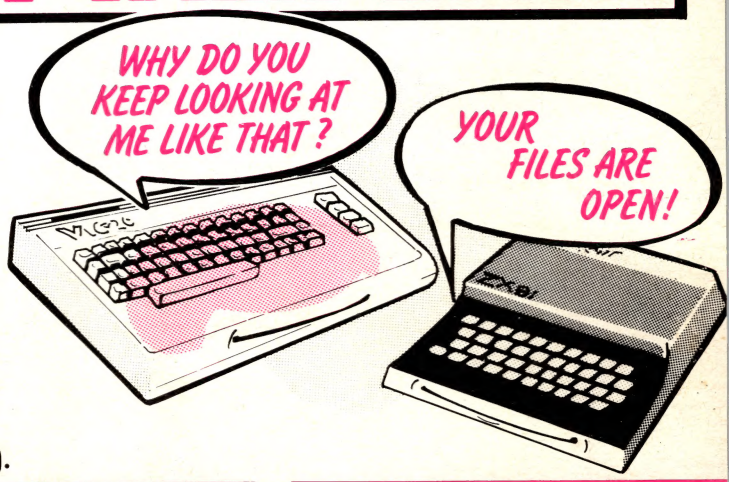
SPEECH SYNTHESISER FOR ZX81 and VIC20

THE MAPLIN TALK-BACK

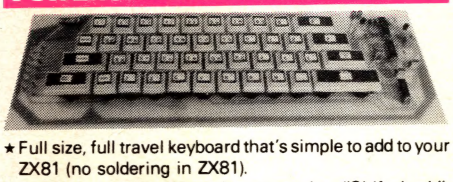
Now your computer can talk!

- ★Allophone (extended phoneme) system gives unlimited vocabulary.
- ★Can be used with unexpanded VIC20 or ZX81 — does not require large areas of memory.
- ★In VIC20 version, speech output is direct to TV speaker with no additional amplification needed.
- ★Allows speech to be easily included in programs.

Complete kit only £24.95.
Order As LK00A (VIC20 Talk-Back).
LK01B (ZX81 Talk-Back).
Full construction details in Maplin Projects Book 6.
Price 70p. Order As XA06G (Maplin Mag Vol. 2 No. 6).



KEYBOARD WITH ELECTRONICS FOR ZX81



★ Full size, full travel keyboard that's simple to add to your ZX81 (no soldering in ZX81).
★ Complete with electronics to make "Shift Lock", "Function" and "Graphics 2" single key selections.
★ Powered (with adaptor supplied) from ZX81's own standard power supply.

Full details in Project Book 3 (XA03D) Price 60p.
Complete kit (excl. case) £19.95. Order As LW72P.
Case £4.95. Order As XG17T.
Ready built-in case £29.95. Order As XG22Y.

OTHER KITS FOR ZX81

3-Channel Sounds Generator (Details in Book 5).
Order As LW96E. Price £10.95.

ZX81 Sound On Your TV Set (Details in Book 6).
Order As LK02C. Price £19.95.

ZX81 I/O Port gives two bi-directional 8-bit ports (Details in Book 4).
Order As LW76H. Price £9.25.

ZX81 Extendiboard will accept 16K RAM and 3 other plug-in modules.
PCB: Order As GB08J. Price £2.32.
Edge Connectors (4 needed): Order As RK35Q. Price £2.39.

HOME SECURITY SYSTEM

Six independent channels – 2 or 4 wire operation. External horn. High degree of protection and long term reliability. Full details in Projects Book 2. (XA02C) Price 60p

MATINEE ORGAN

Easy-to-build, superb specification. Comparable with organs selling for up to £1000. Full construction details in our book (XH55K). Price £2.50. Complete kits available. Electronics (XY91Y) £299.95*. Cabinet (XY93B) £99.50*. Demo cassette (XX43W) £1.99.

*Carriage extra

25W STEREO MOSFET AMPLIFIER

★ Over 26W/channel into 8Ω at 1kHz both channels driven
★ Frequency response 20Hz to 40kHz ± 1dB.
★ Low distortion, low noise and high reliability power MOSFET output stage.
★ Extremely easy to build. Almost everything fits on main pcb, cutting interwiring to just 7 wires (plus toroidal transformer and mains lead terminations).
★ Complete kit contains everything you need including pre-drilled and printed chassis and wooden cabinet.

Full details in Projects Book 3. Price 60p (XA03D).
Complete kit only £49.95 incl. VAT and carriage (LW71N).

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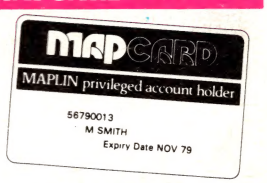

MAPLIN'S FANTASTIC PROJECTS

Full details in our project books. Issues 1 to 5: 60p each Issue 6: 70p.

In Book 1 (XA01B) 120W rms MOSFET Combo Amplifier ●Universal Timer with 18 program times and 4 outputs ●Temperature Gauge ●Six Vero Projects.

In Book 2 (XA02C) Home Security System ● Train Controller for 14 trains on one circuit ●Stopwatch with multiple modes ●Miles-per-Gallon Meter.

In Book 3 (XA03D) ZX81 Keyboard with electronics Stereo 25W MOSFET Amplifier ●Doppler Radar Intruder Detector ●Remote Control for Train Controller.

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